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Bollman

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(45) **Date of Patent: May 7, 2019**

(54) **THREE-DIMENSIONAL POSITIONING AND HOLDING MODULE SYSTEM FOR MODULAR WORKSTATIONS**

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(72) Inventor: **Clifford Bollman**, Vancouver, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/823,302**

(22) Filed: **Nov. 27, 2017**

Related U.S. Application Data

(63) Continuation-in-part of application No. 15/466,609, filed on Mar. 22, 2017, now Pat. No. 9,829,025, which is a continuation of application No. 15/080,506, filed on Mar. 24, 2016, now Pat. No. 9,637,921.

(60) Provisional application No. 62/590,983, filed on Nov. 27, 2017.

(51) **Int. Cl.**

F16M 11/00	(2006.01)
F16B 12/44	(2006.01)
A47B 13/02	(2006.01)
E04C 3/04	(2006.01)
E04B 1/24	(2006.01)
A47B 21/04	(2006.01)
E04C 3/29	(2006.01)
F16B 7/18	(2006.01)

(52) **U.S. Cl.**
CPC ***F16B 12/44*** (2013.01); ***A47B 13/02*** (2013.01); ***A47B 21/04*** (2013.01); ***E04B 1/24*** (2013.01); ***E04C 3/04*** (2013.01); ***E04C 3/29*** (2013.01); *A47B 2200/0016* (2013.01); *E04B 2001/2472* (2013.01); *E04C 2003/0413* (2013.01); *E04C 2003/0421* (2013.01); *E04C 2003/0439* (2013.01); *E04C 2003/0465* (2013.01); *F16B 7/187* (2013.01)

(58) **Field of Classification Search**
CPC E04G 3/28; F16B 12/44; A47B 13/02
See application file for complete search history.

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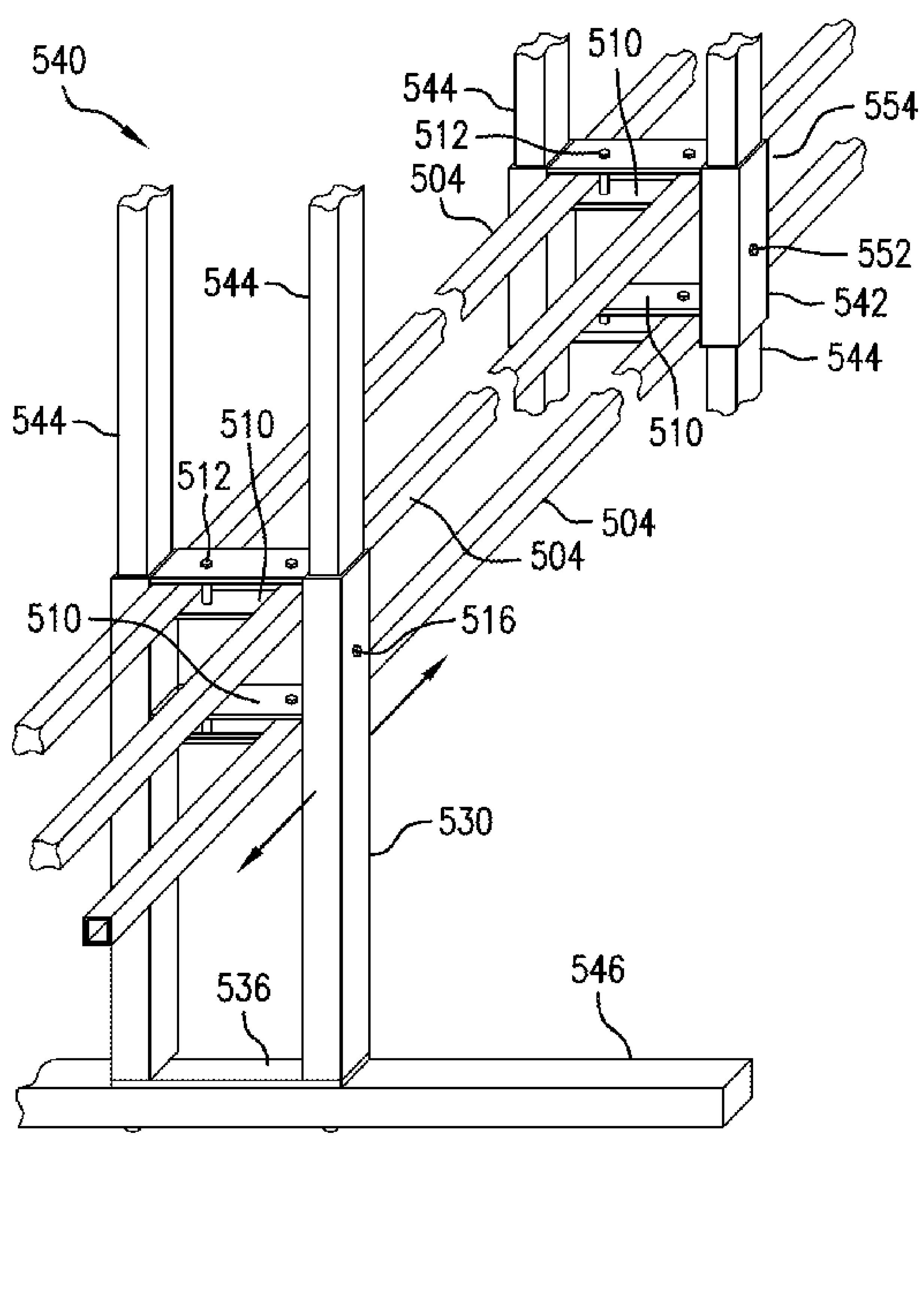
(57) **ABSTRACT**

A Three-Dimensional Positioning and Holding Modular System for office and industrial work stations including embodiments of multi-rail beams and rail-arm-leg modules. The embodiments have tubes, bars, or channels arranged and connected in ways that provide improved ability to transmit torque along a long axis of the multi-rail beam while providing improved resistance to twisting under the forces of the torque.

17 Claims, 32 Drawing Sheets



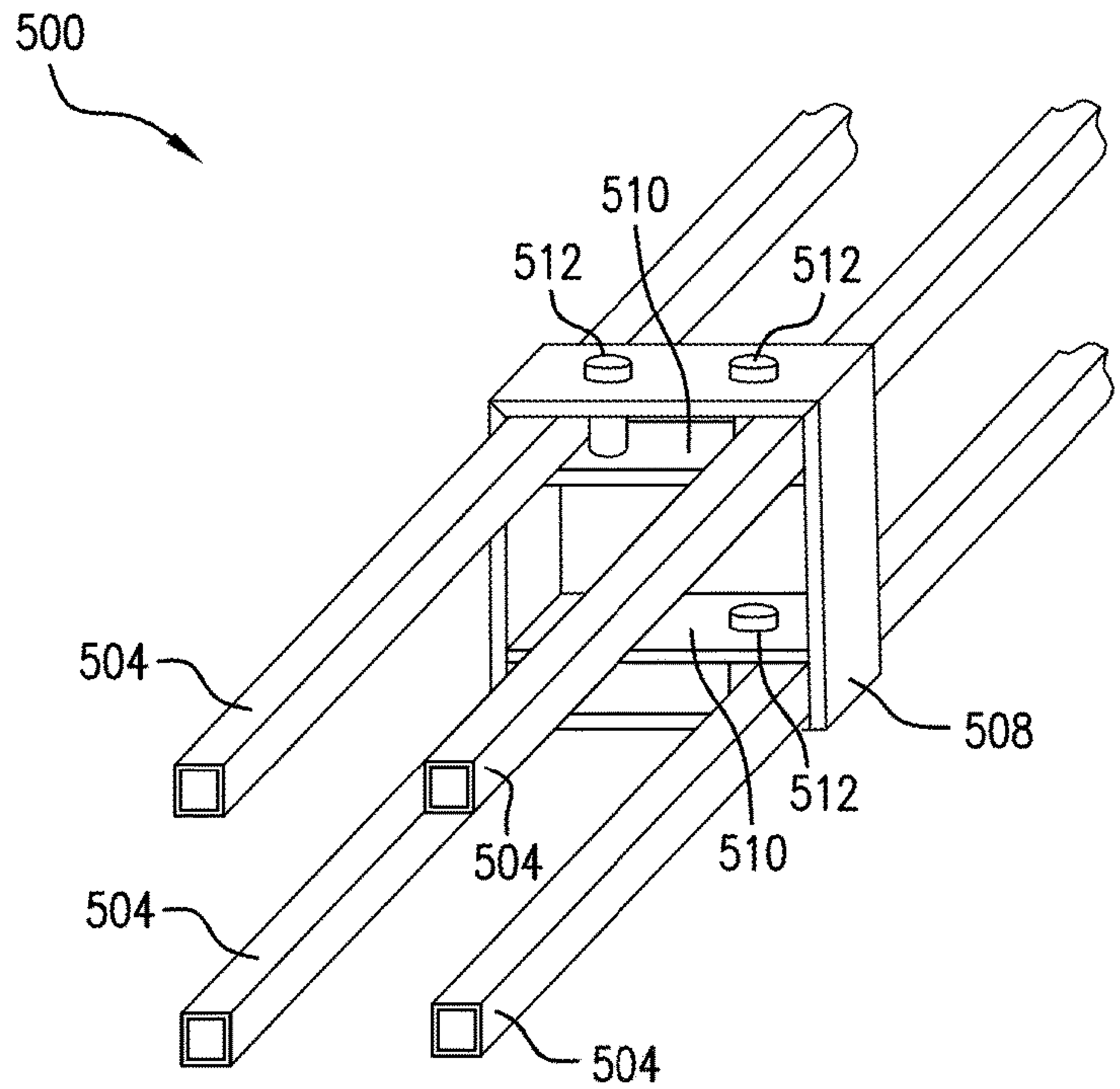


FIG.1

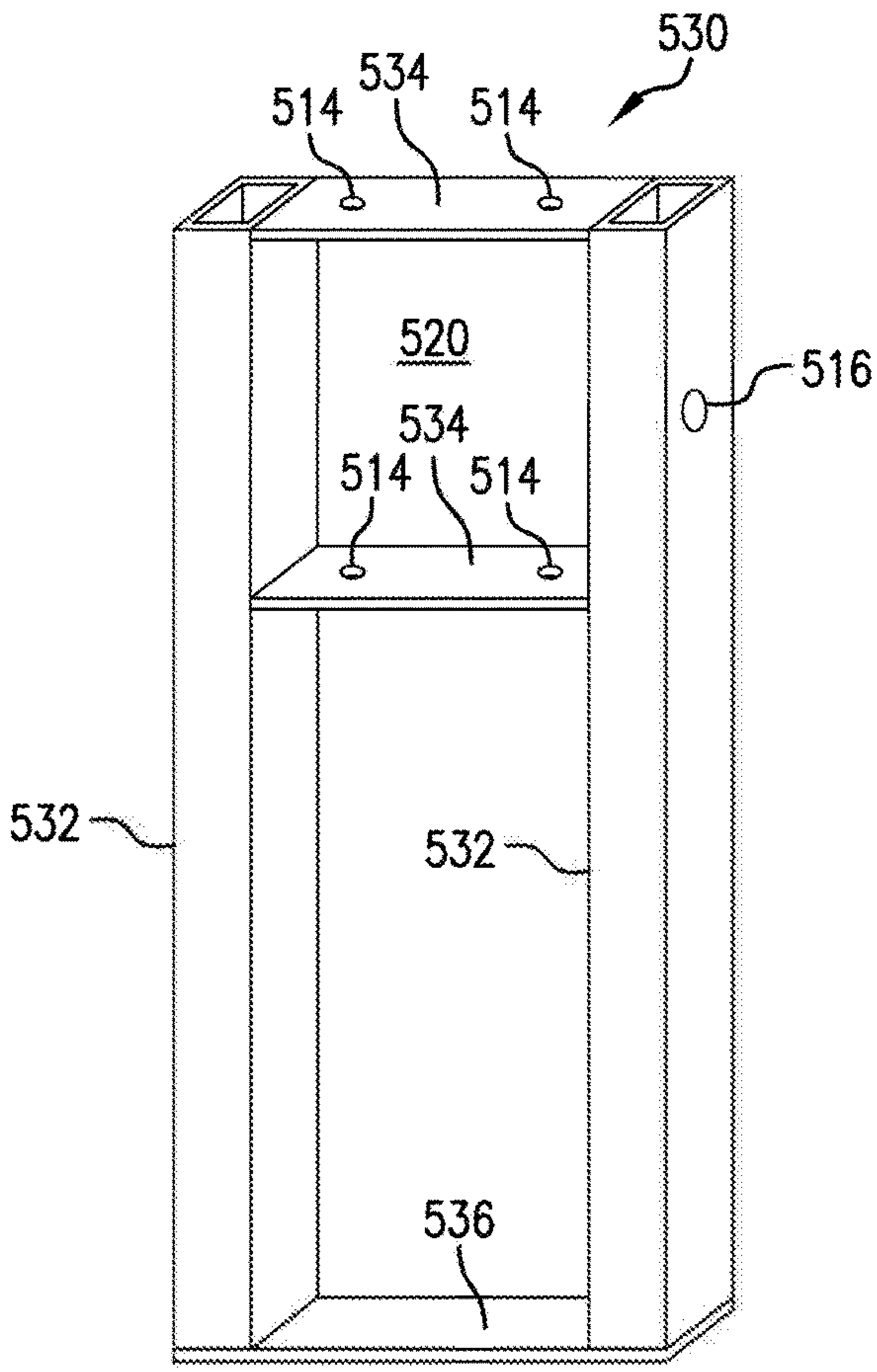

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FIG.2A

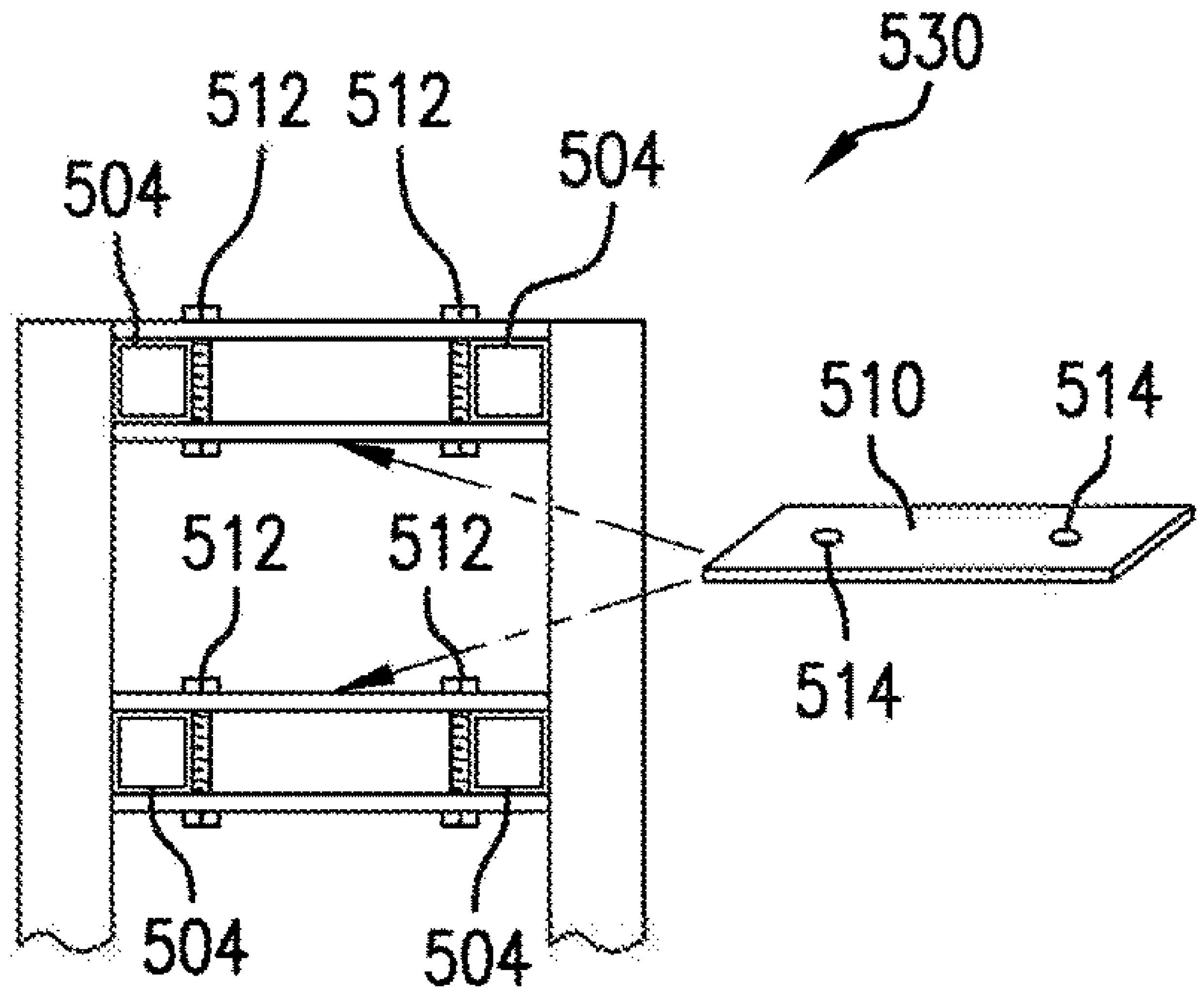
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FIG.2B

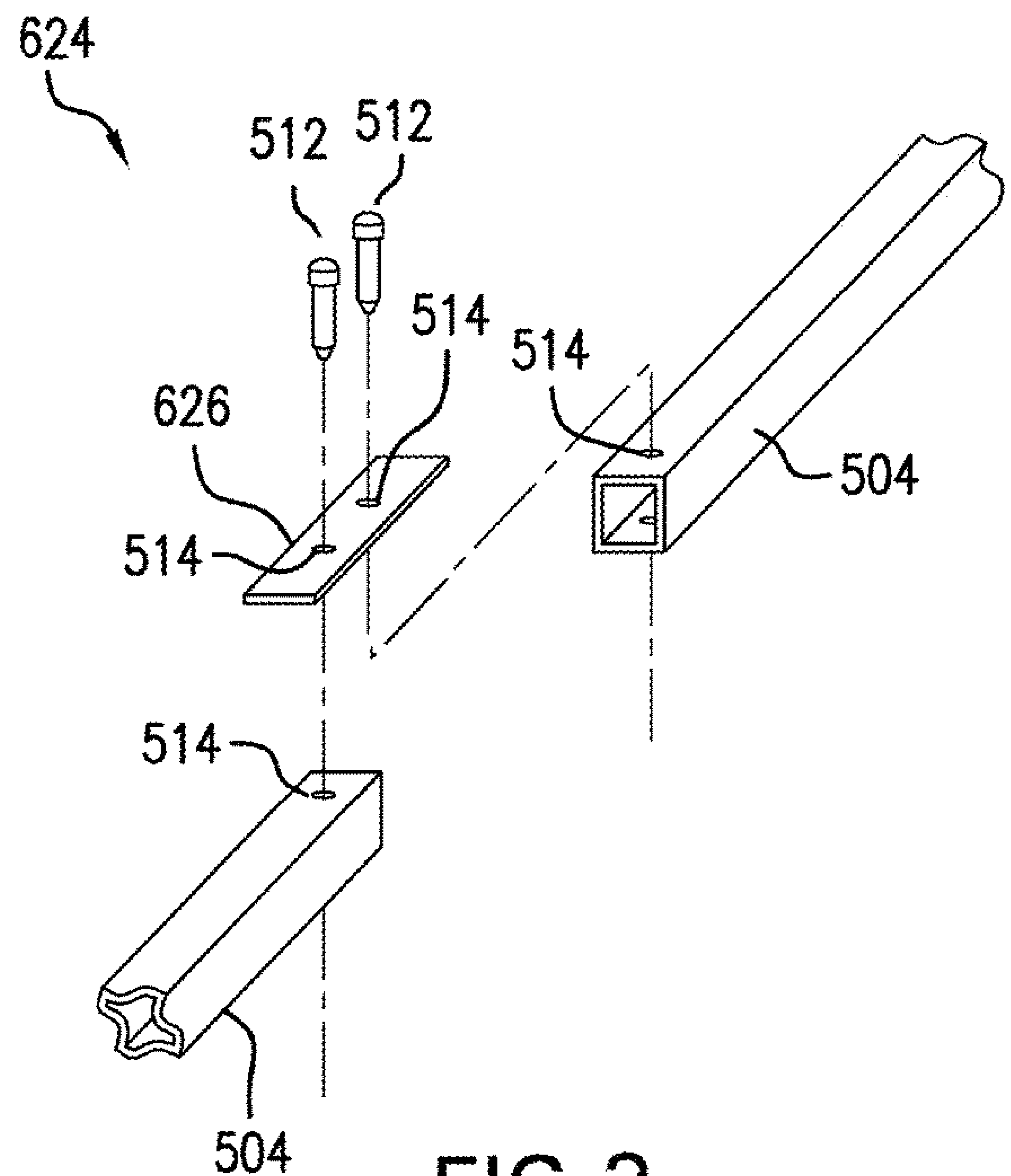
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FIG.3

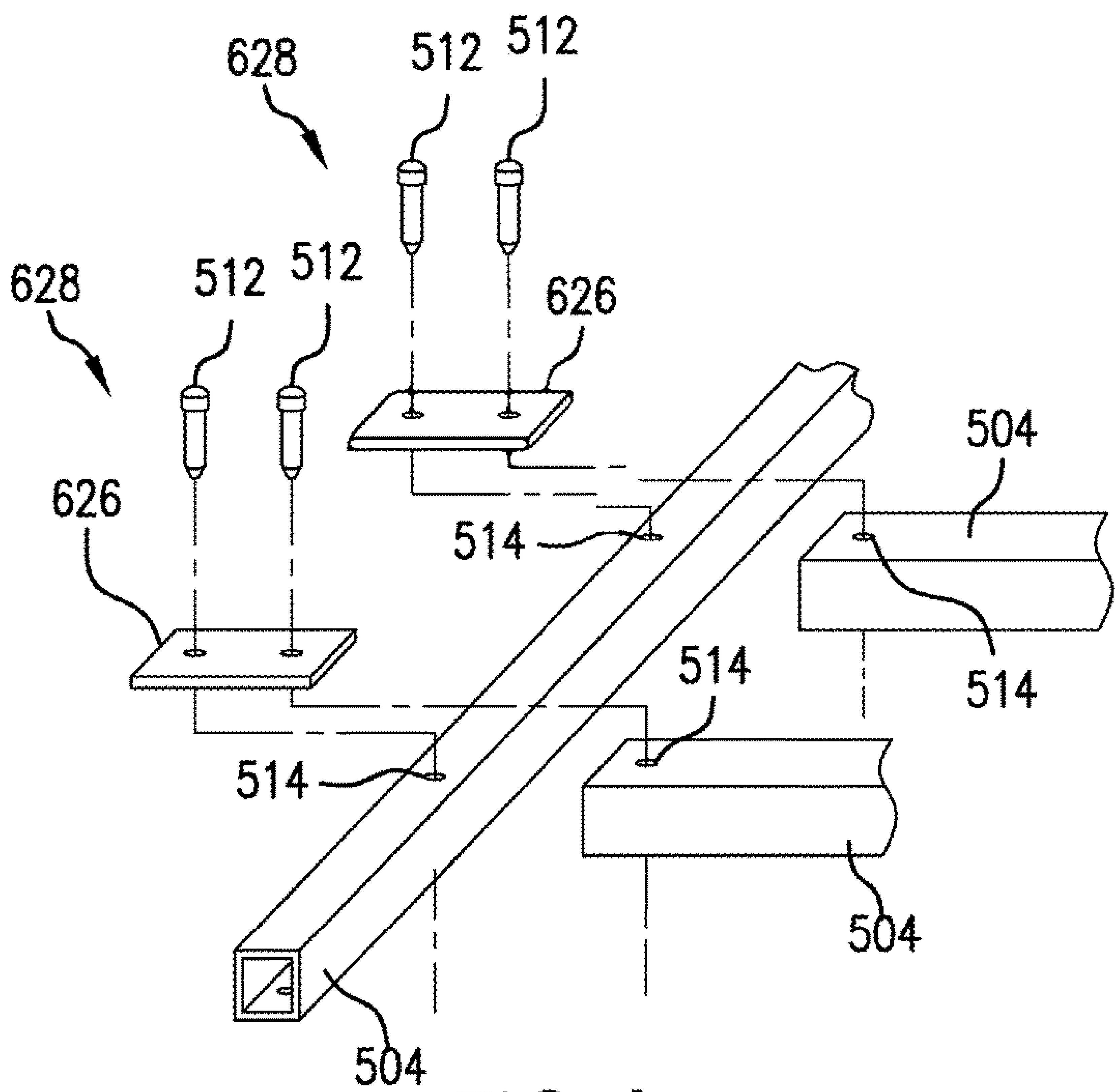
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FIG.4

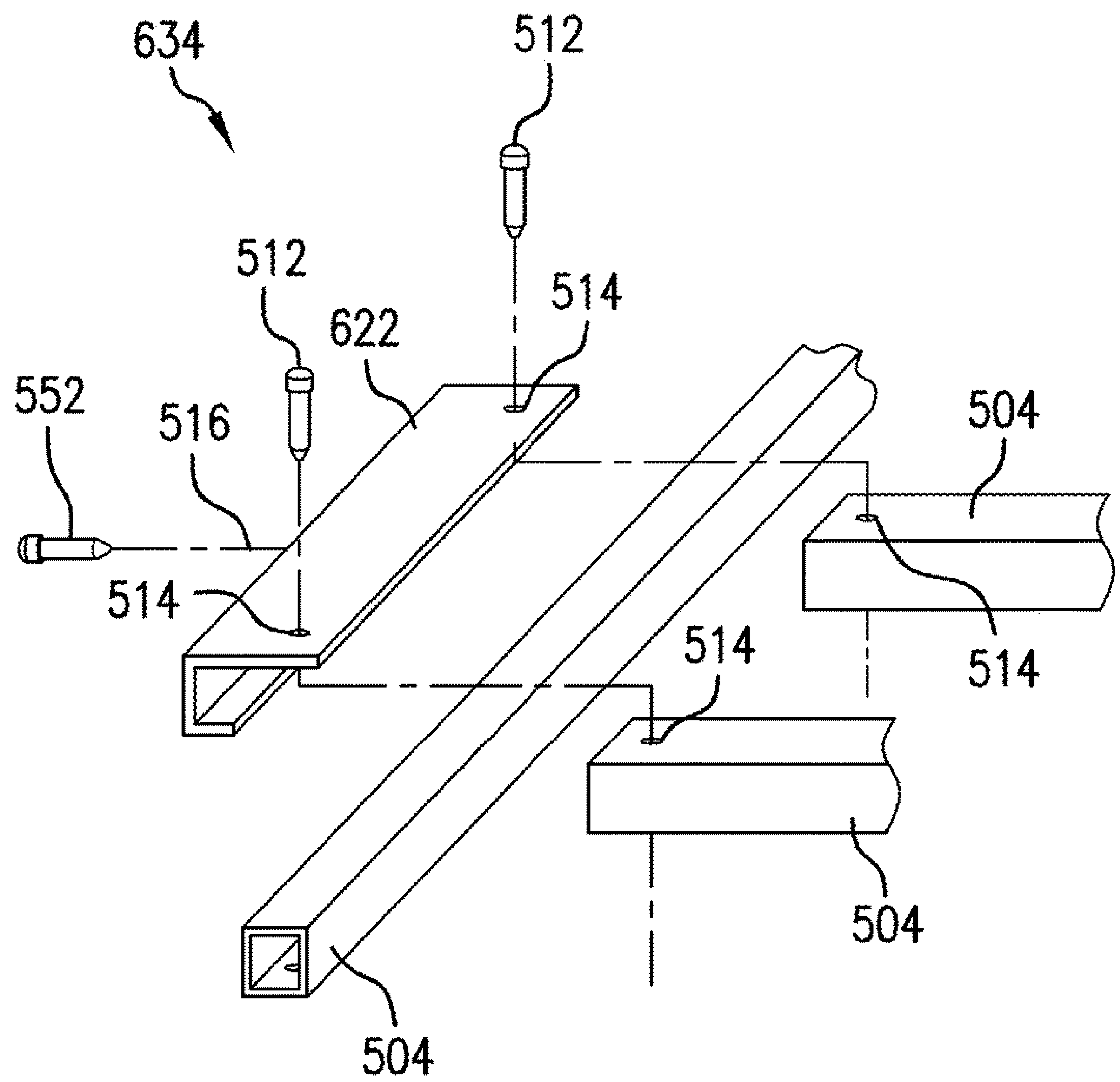

FIG. 5

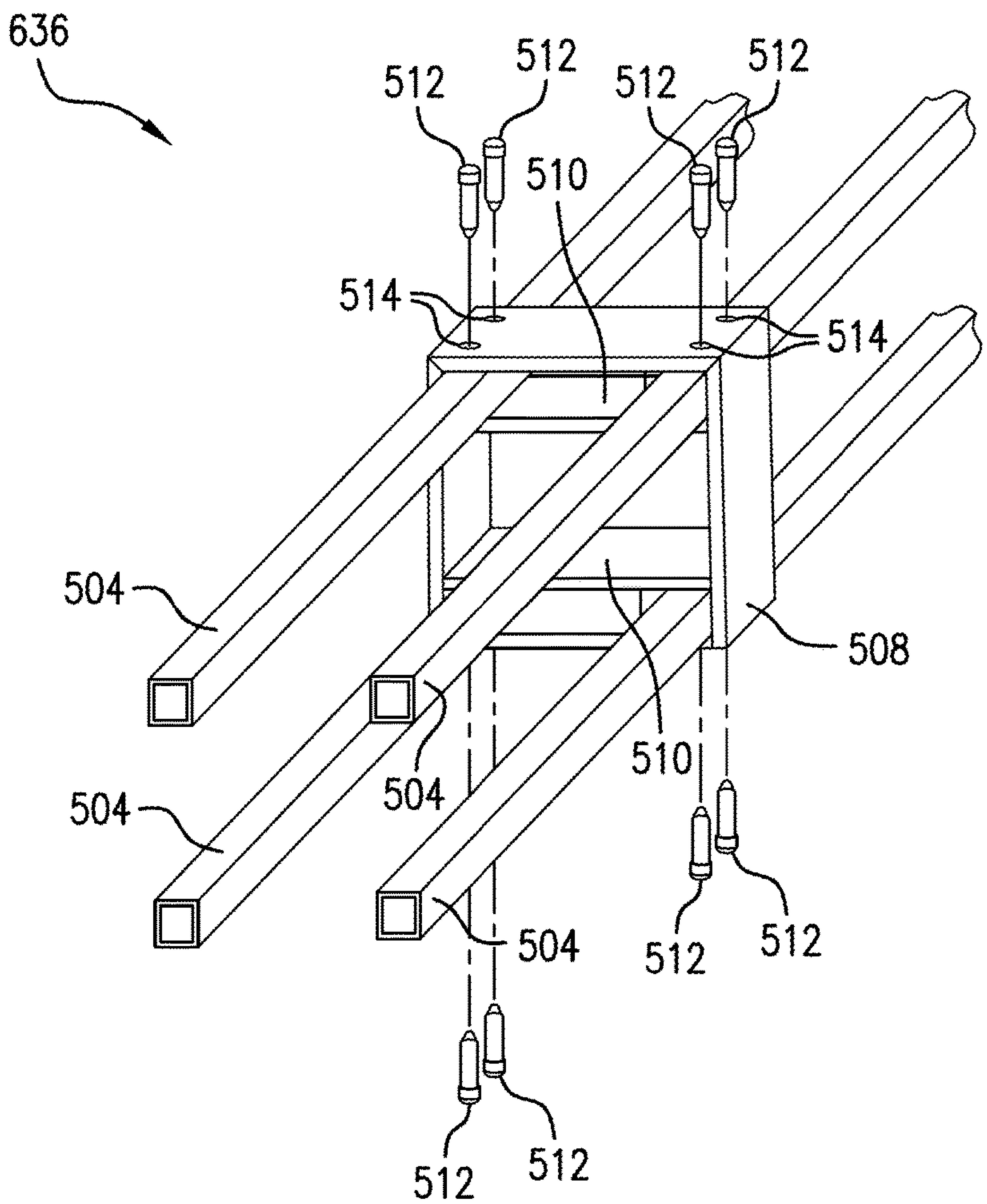
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FIG.6

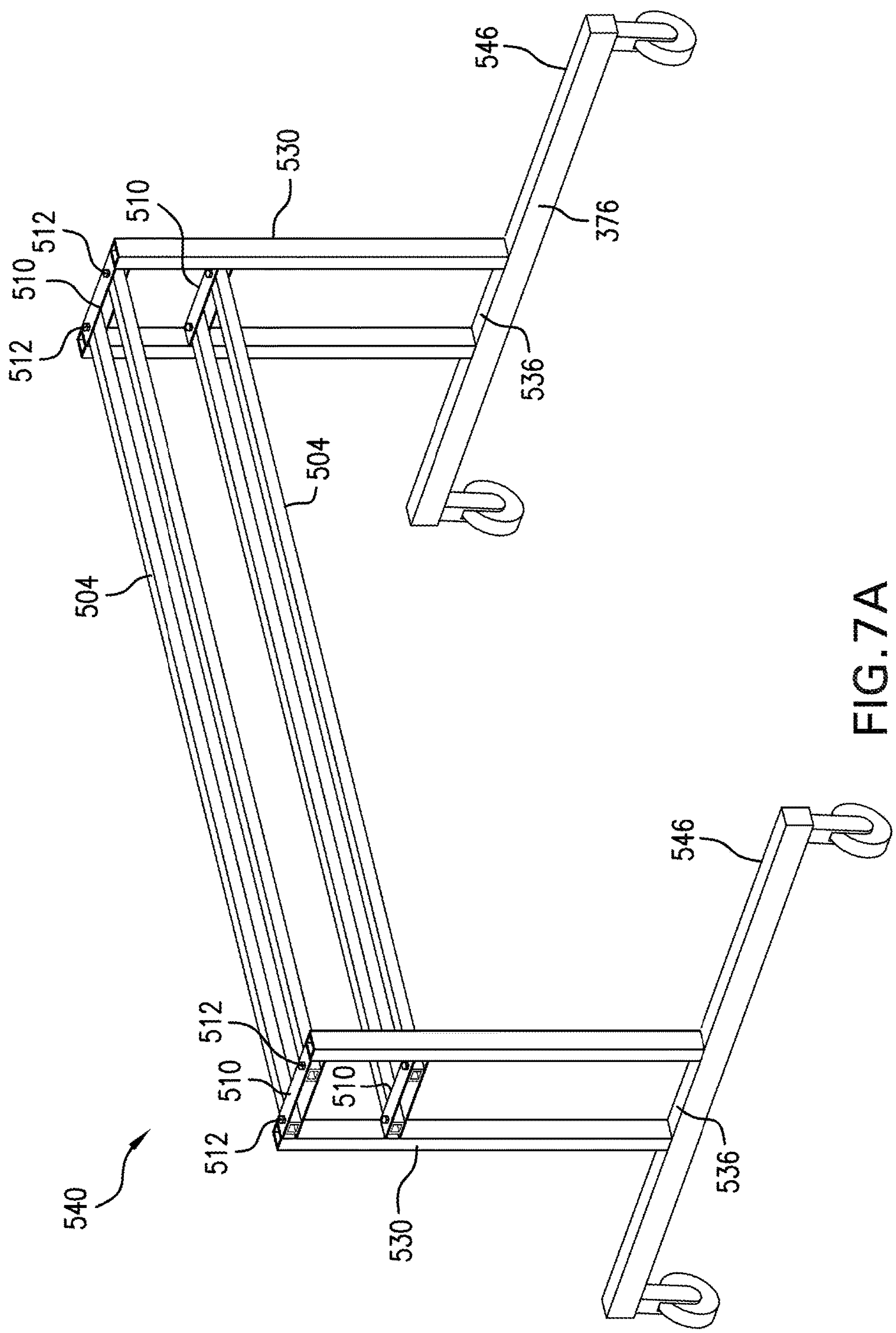
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FIG. 7A

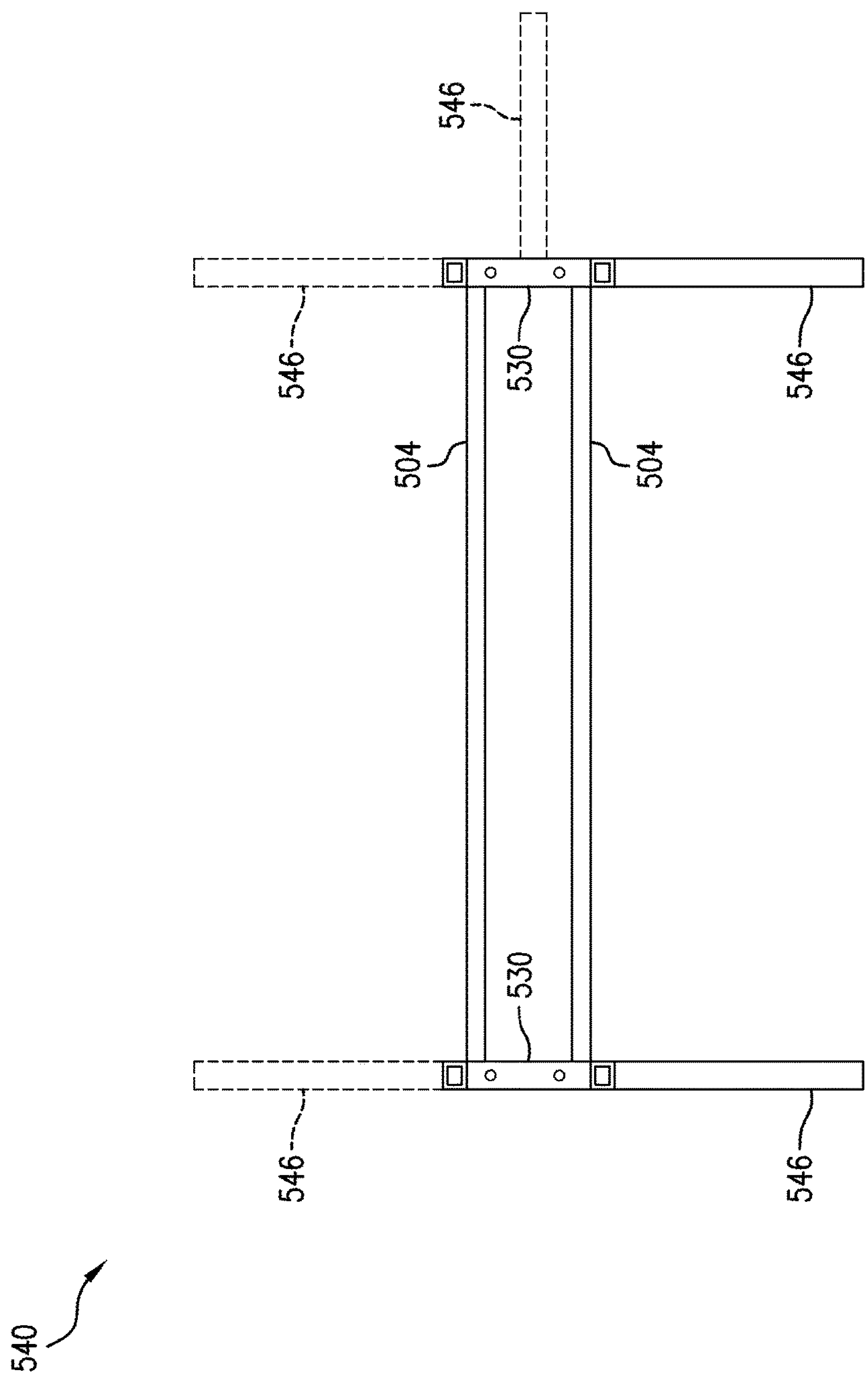

FIG. 7B

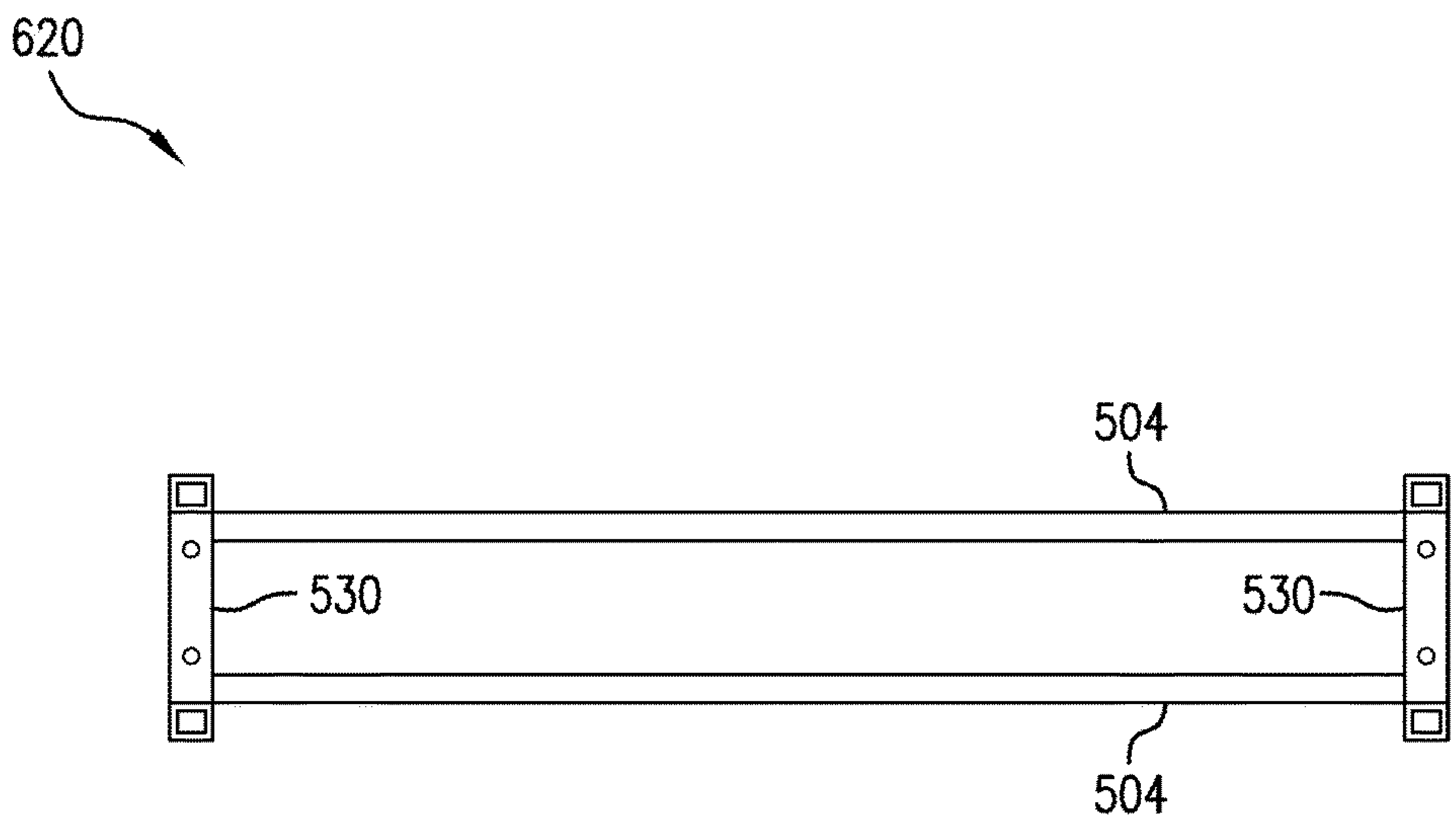

FIG.8

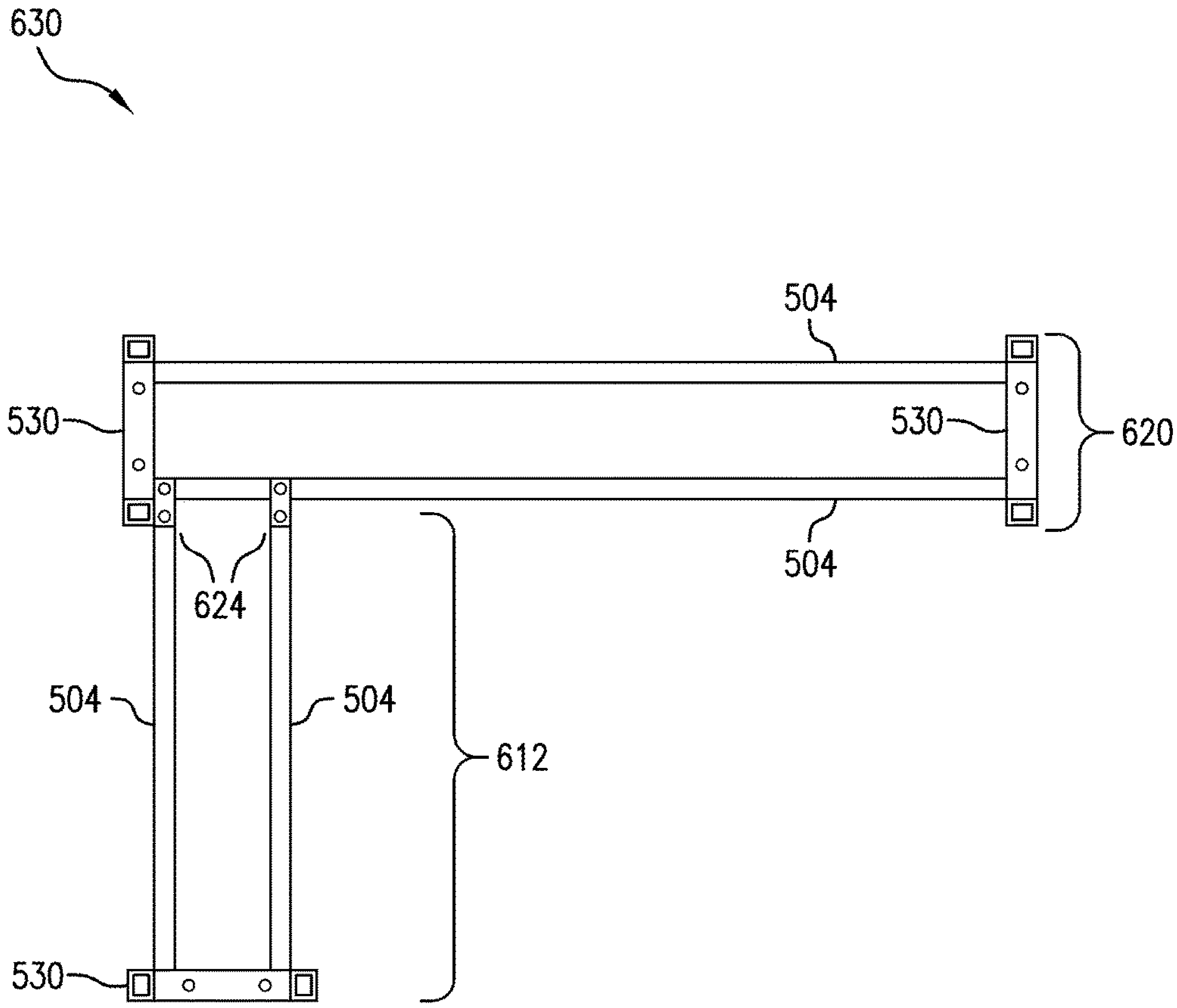

FIG.9A

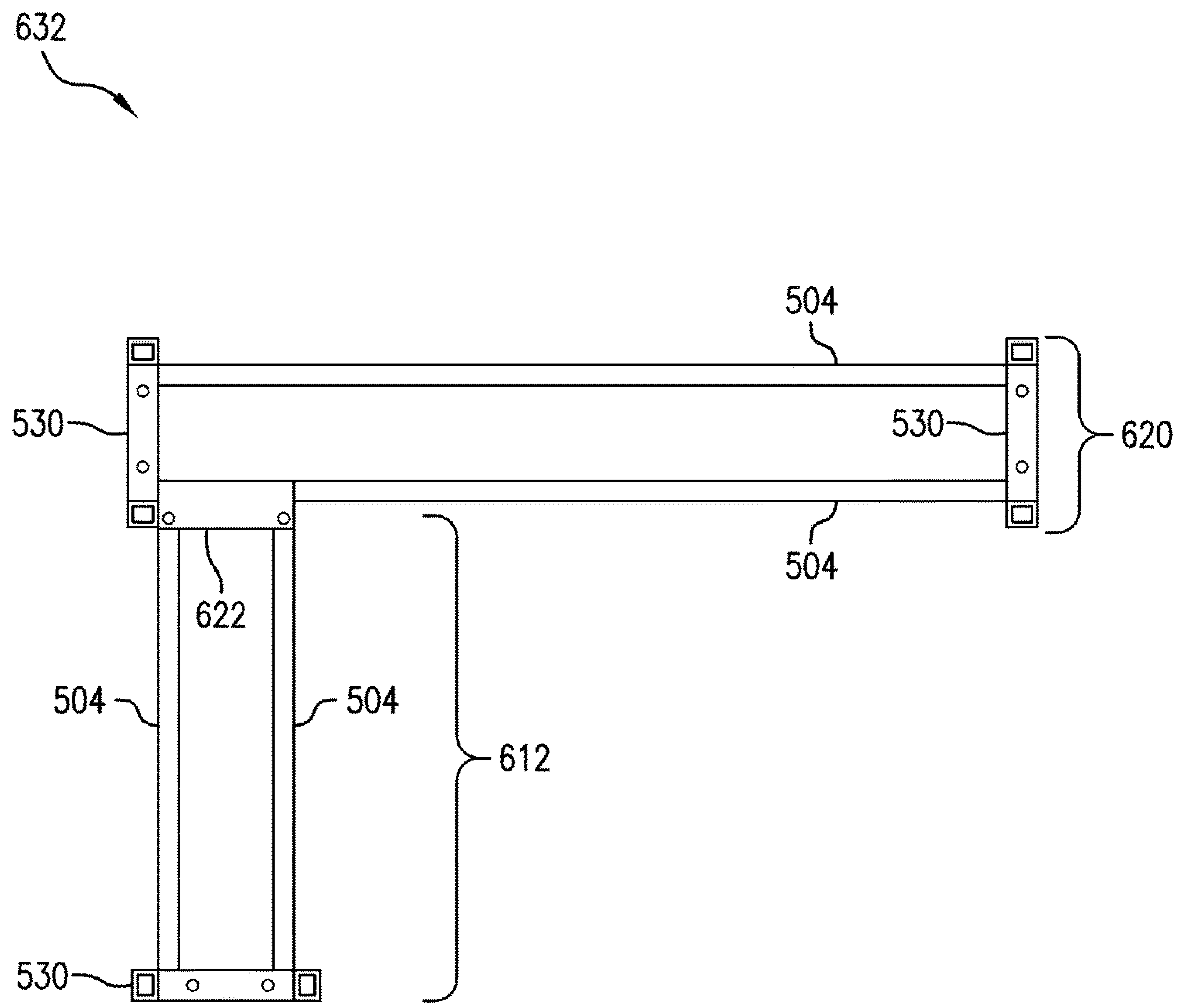

FIG.9B

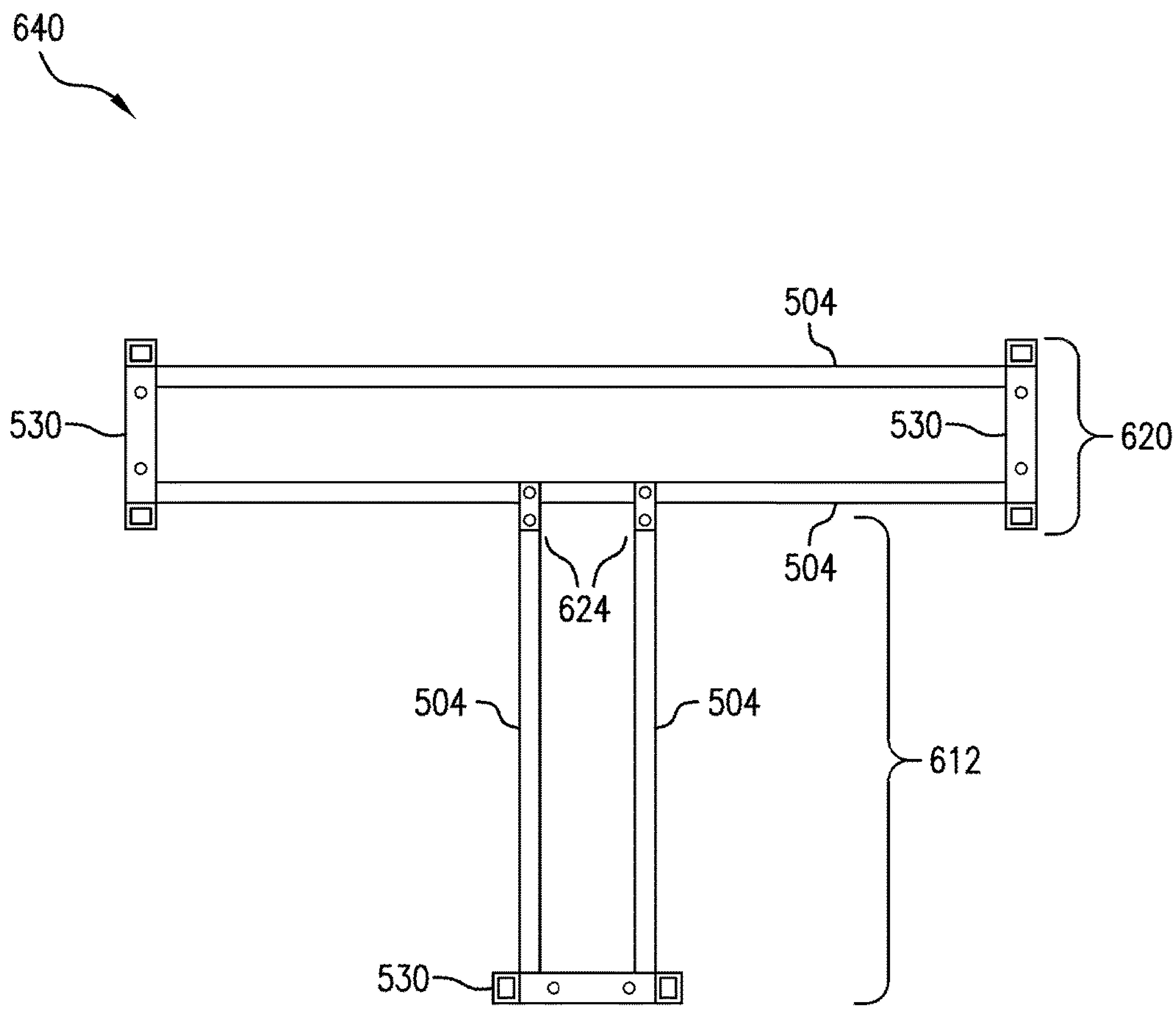

FIG.10A

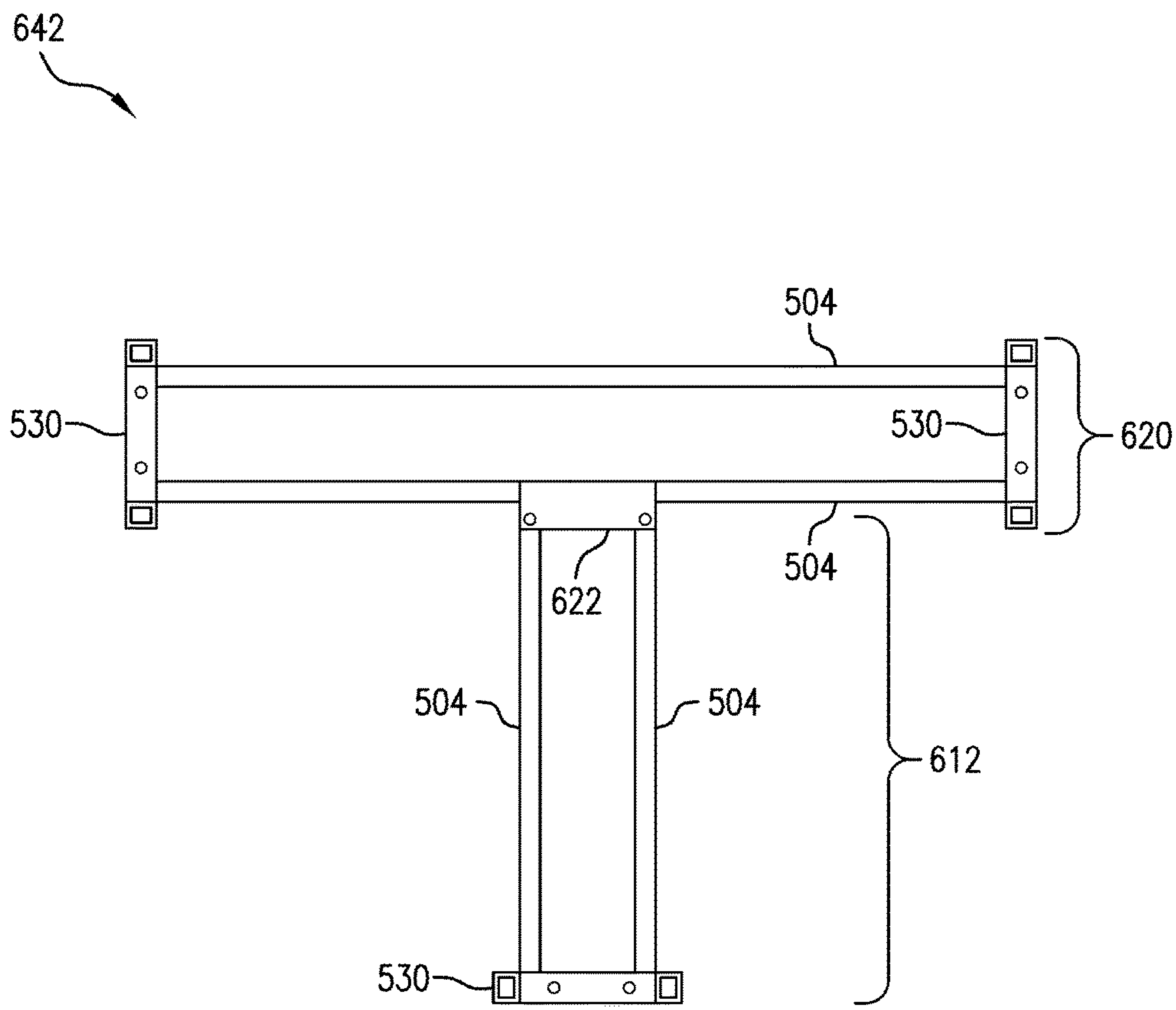

FIG.10B

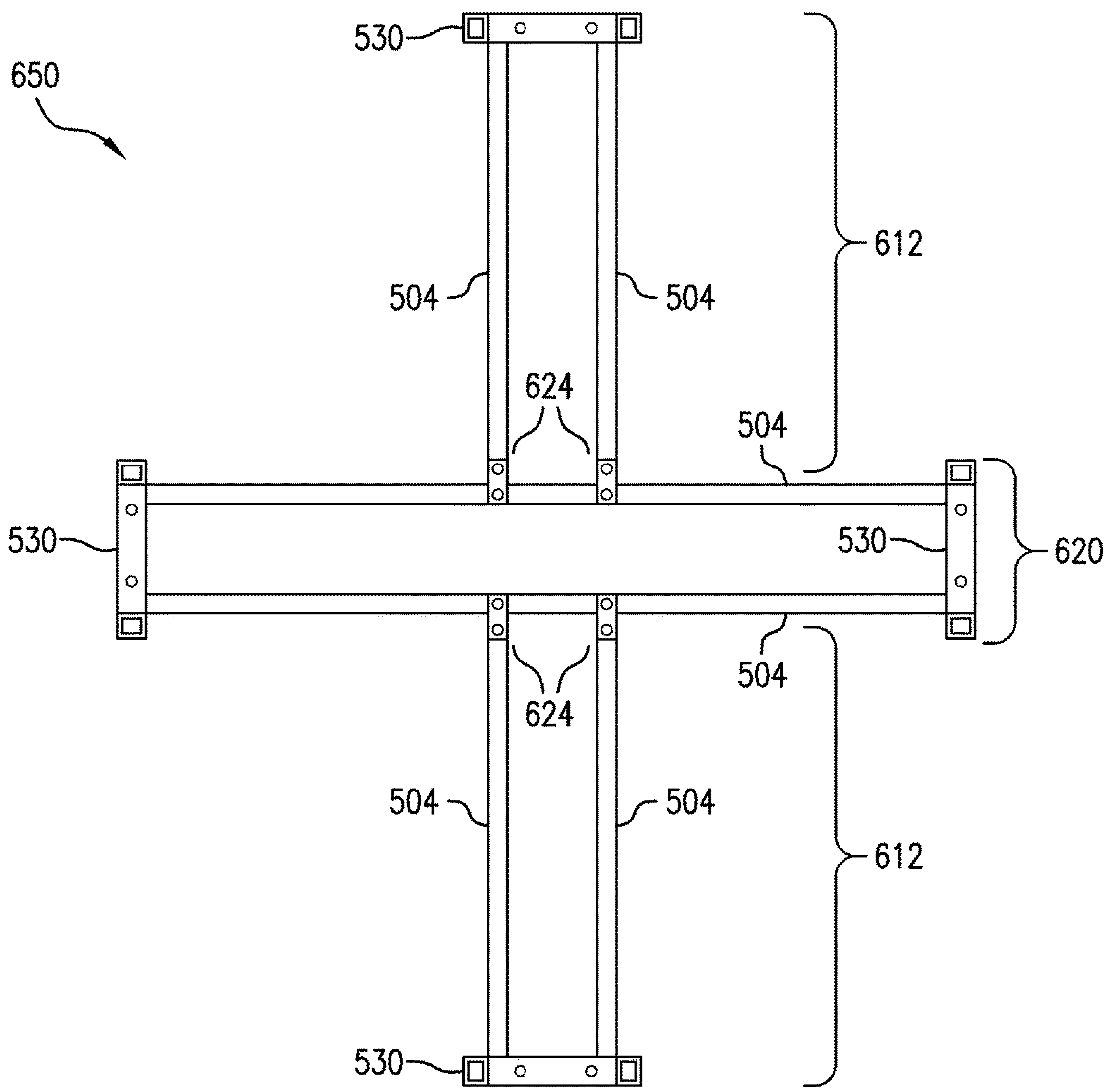

FIG.11A

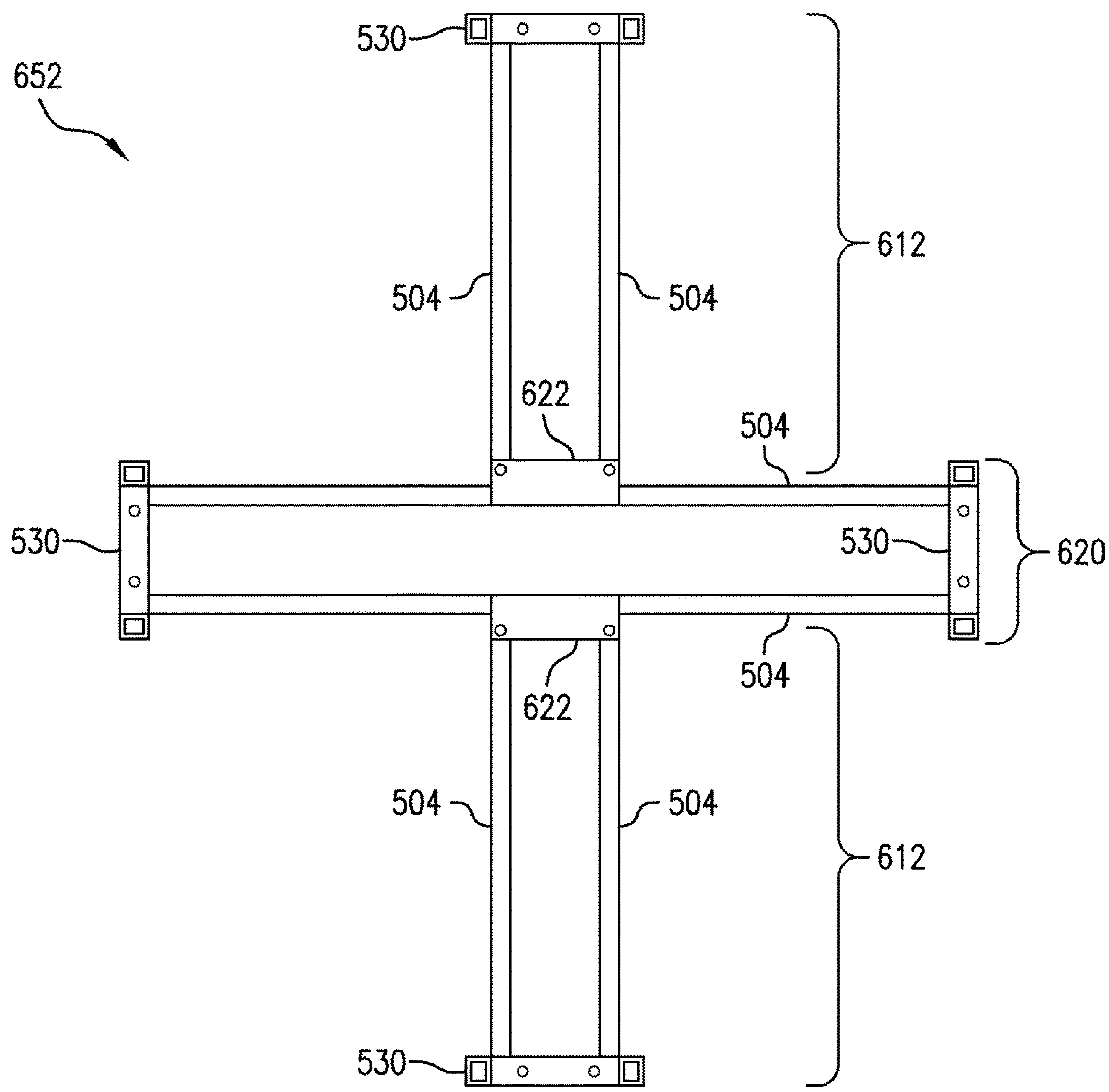

FIG.11B

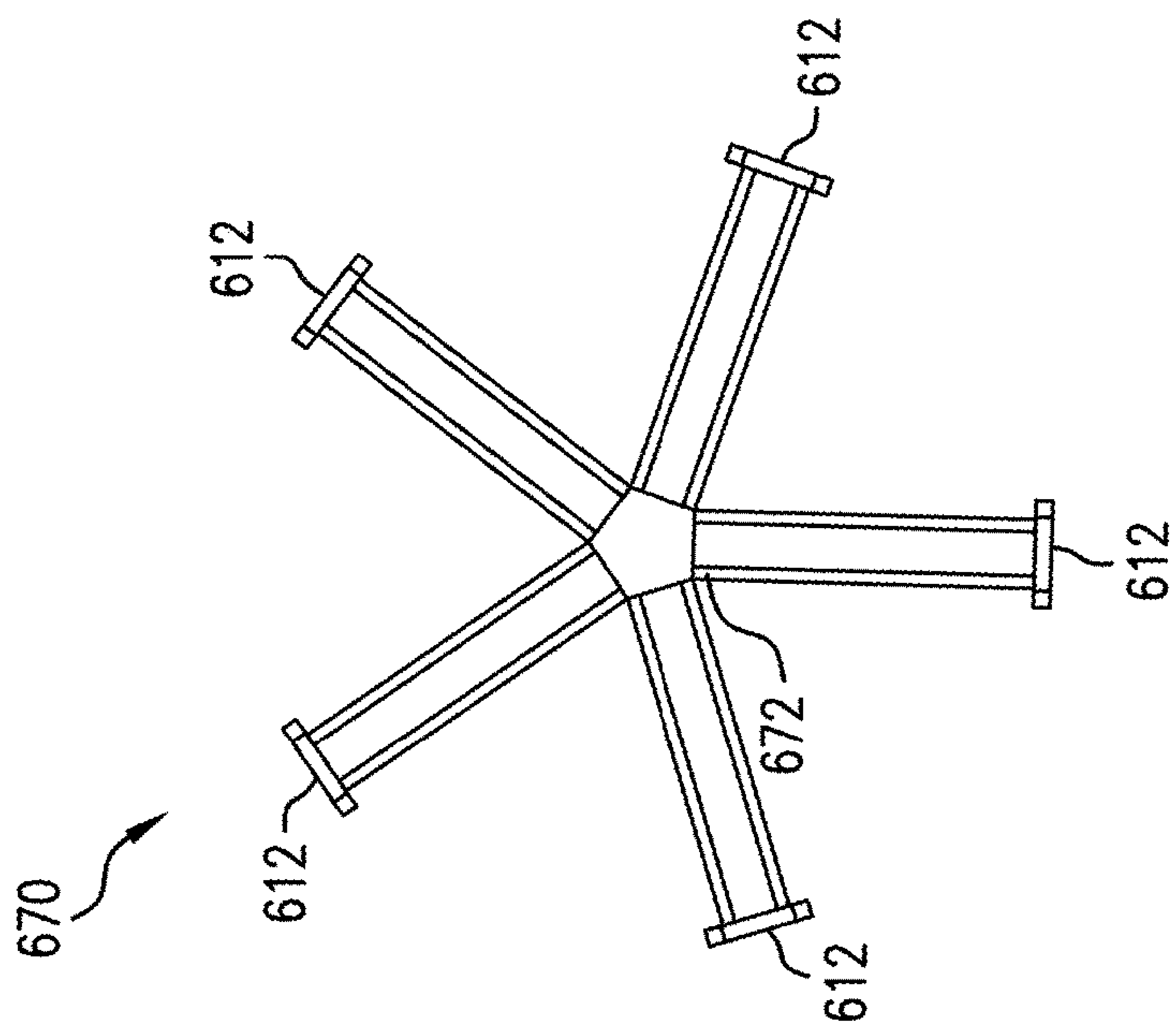

FIG. 13

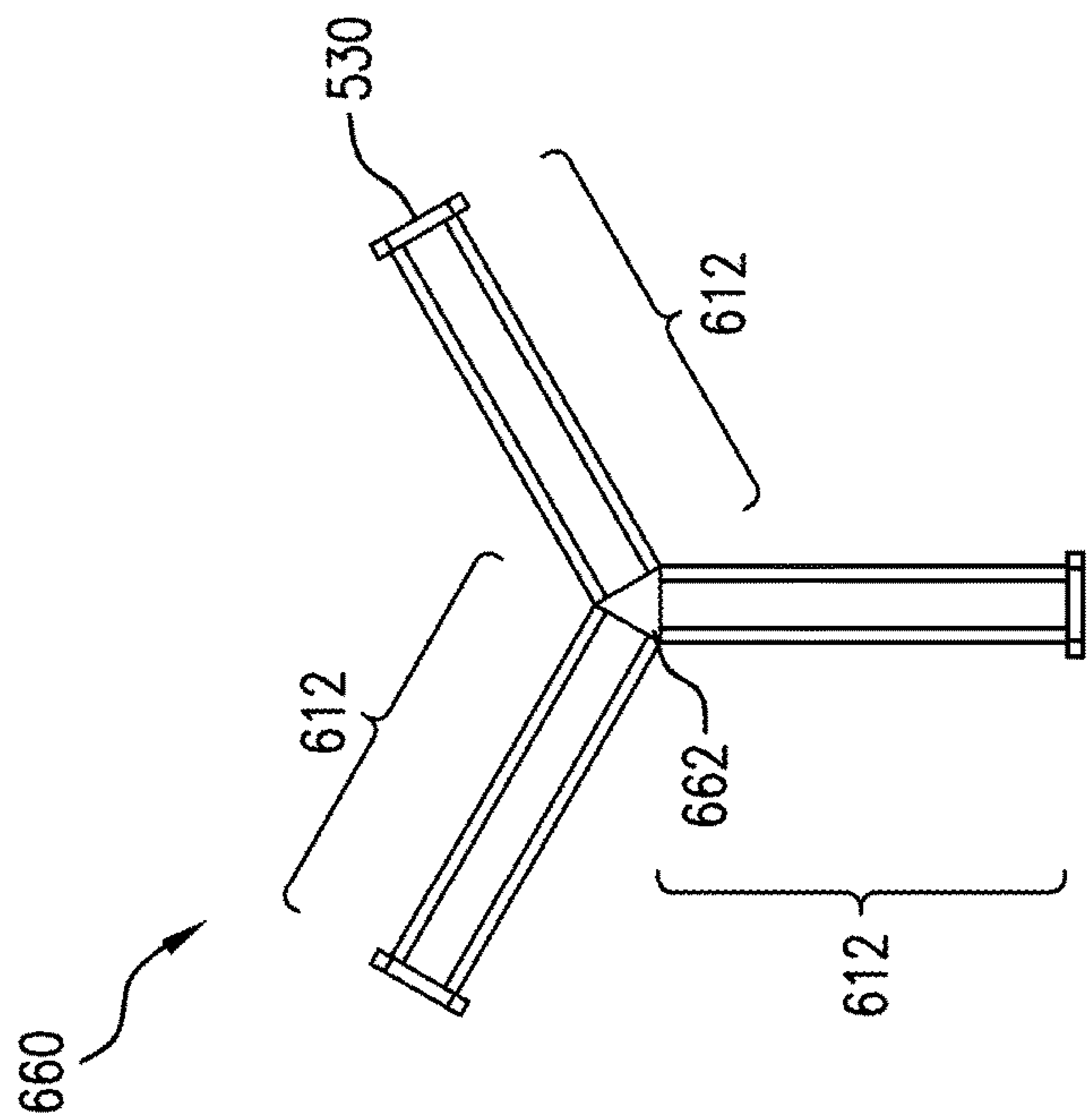

FIG. 12

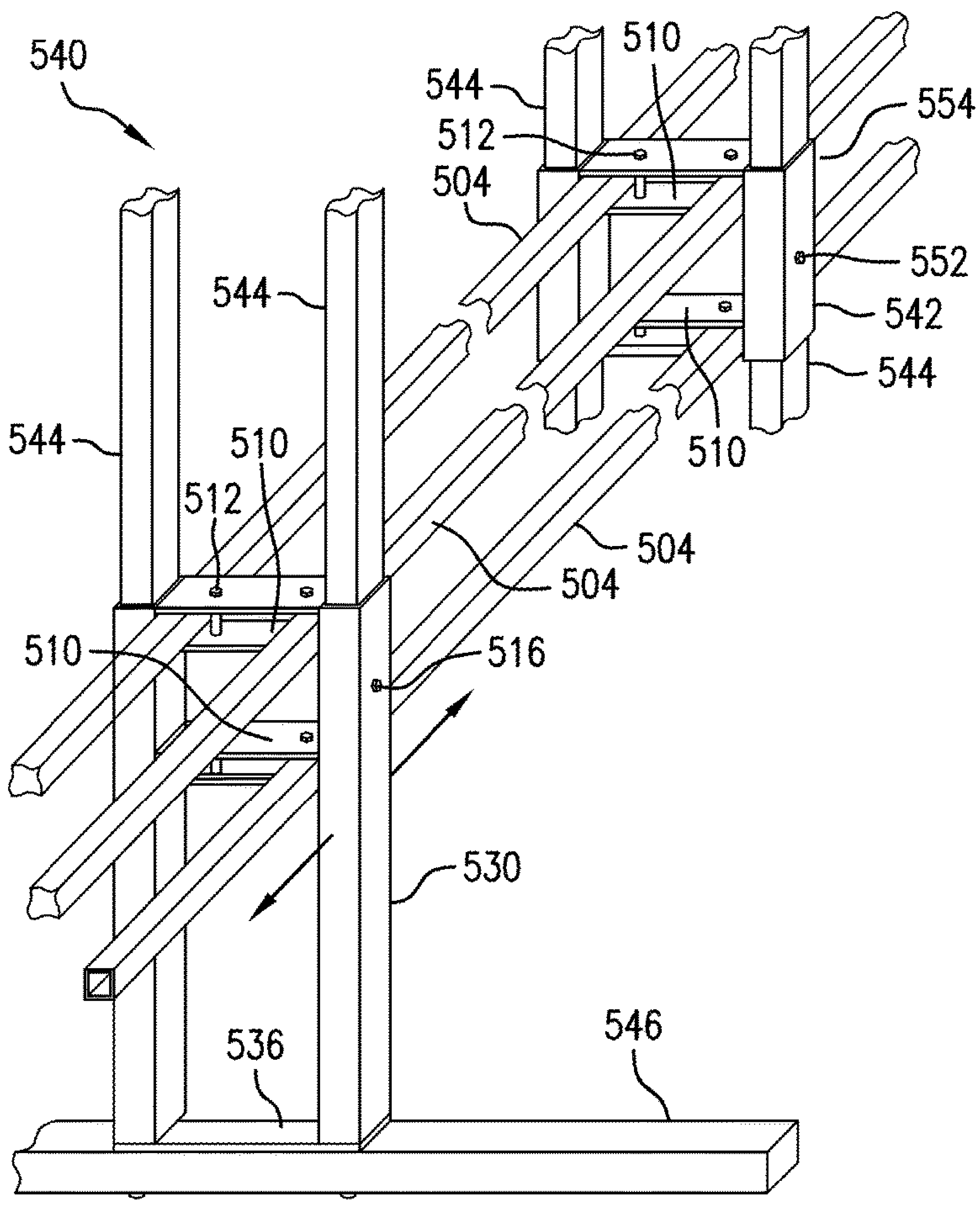
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FIG.14

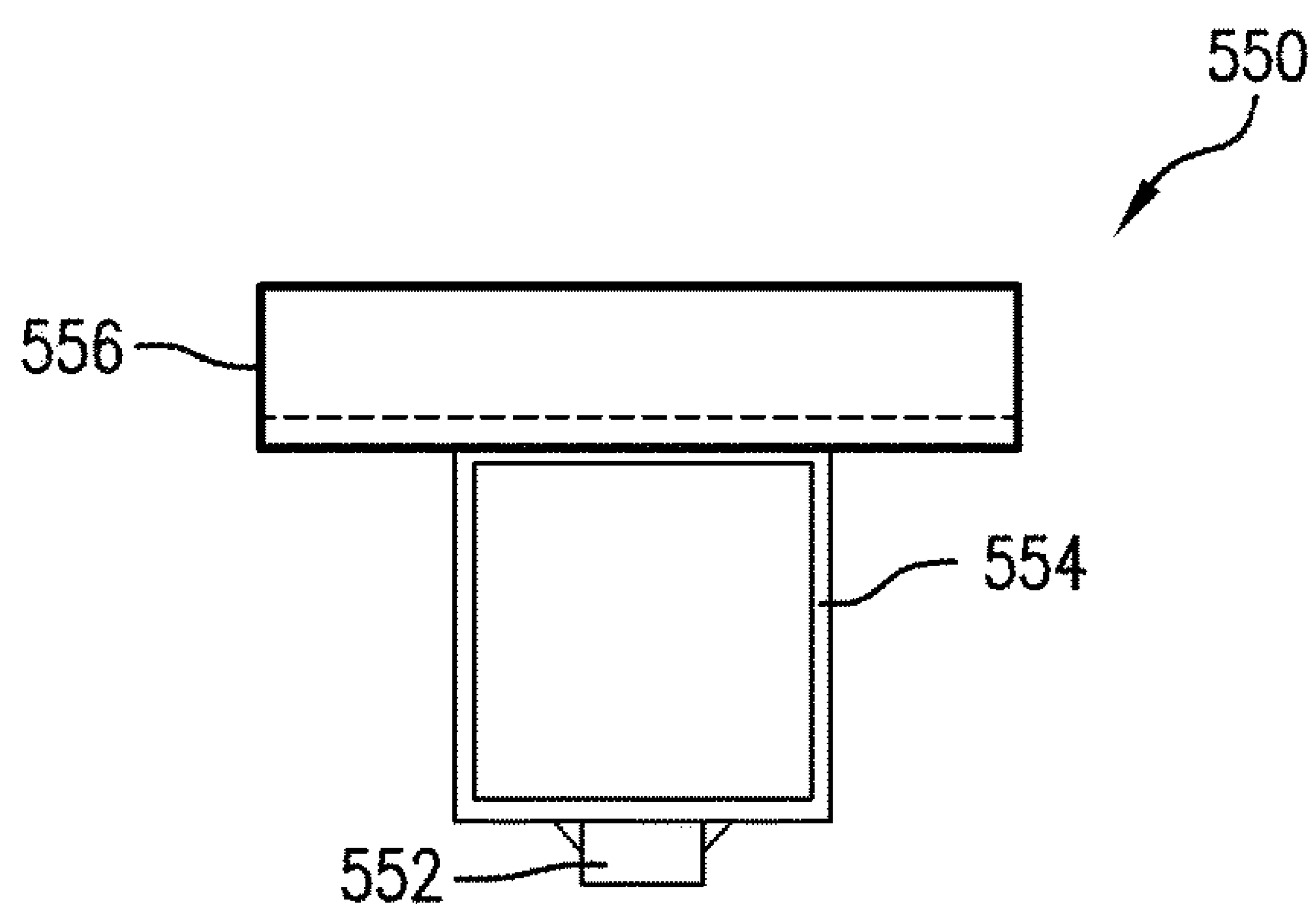

FIG.15A

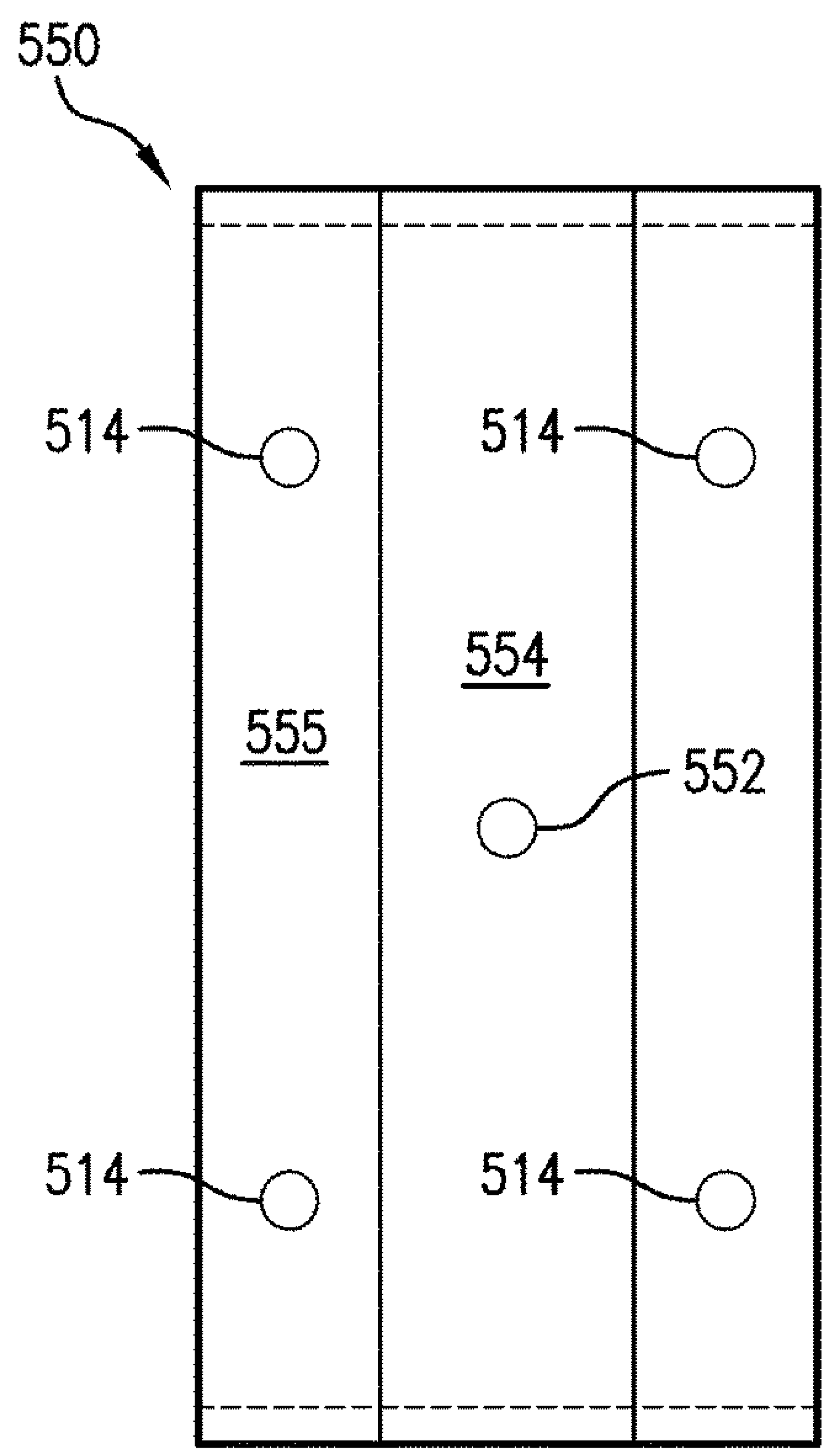

FIG.15B

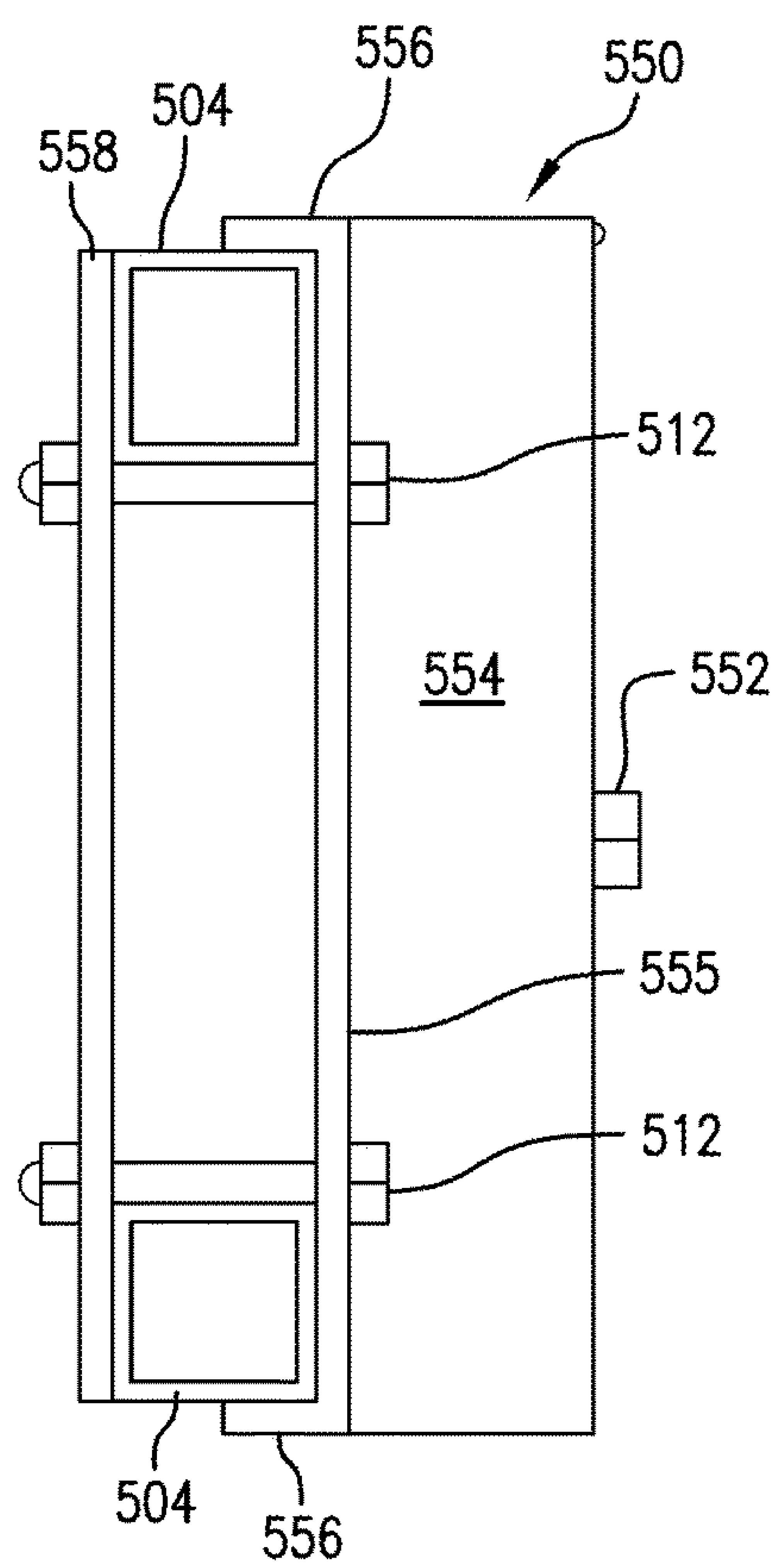

FIG.15C

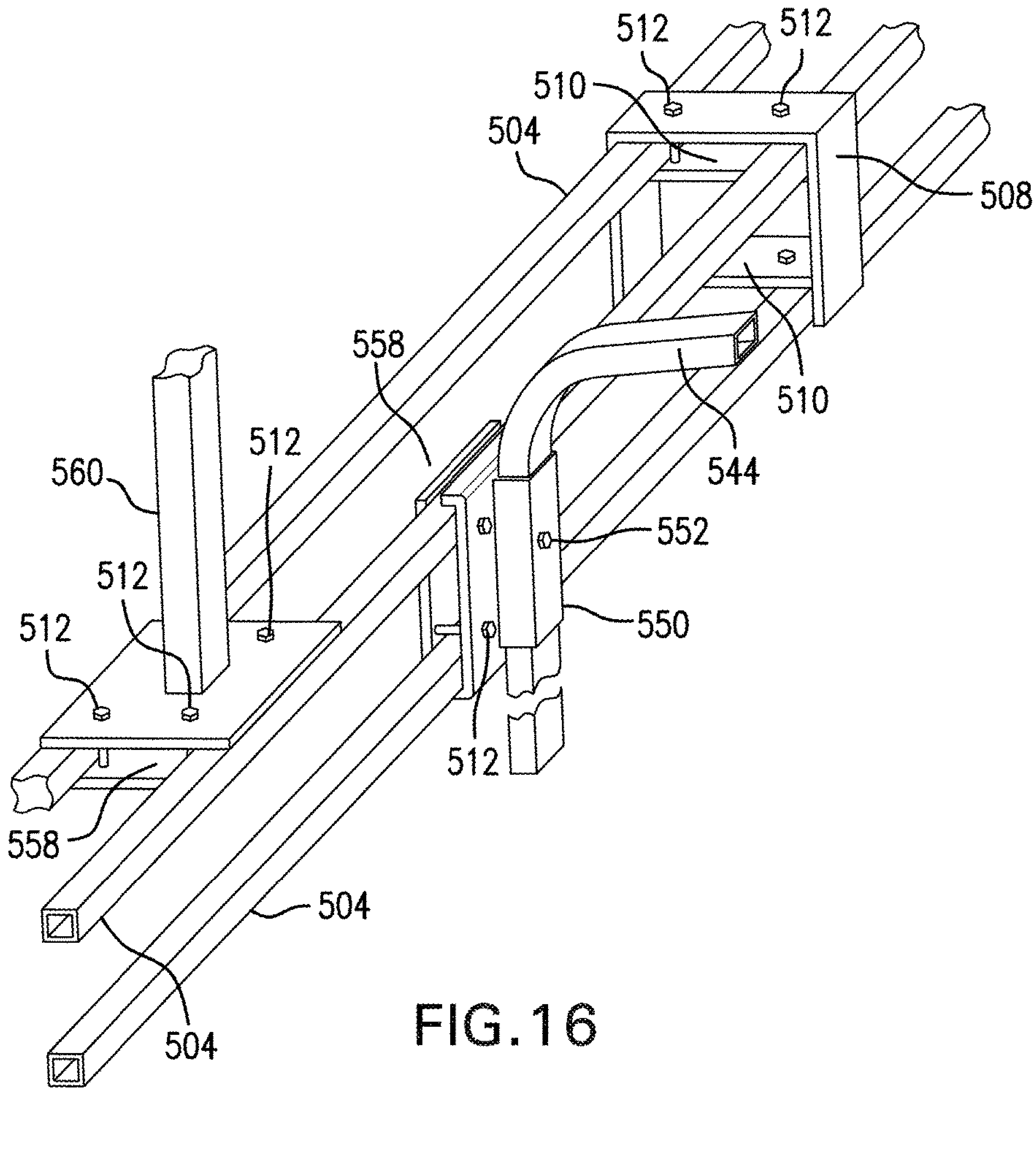
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FIG.16

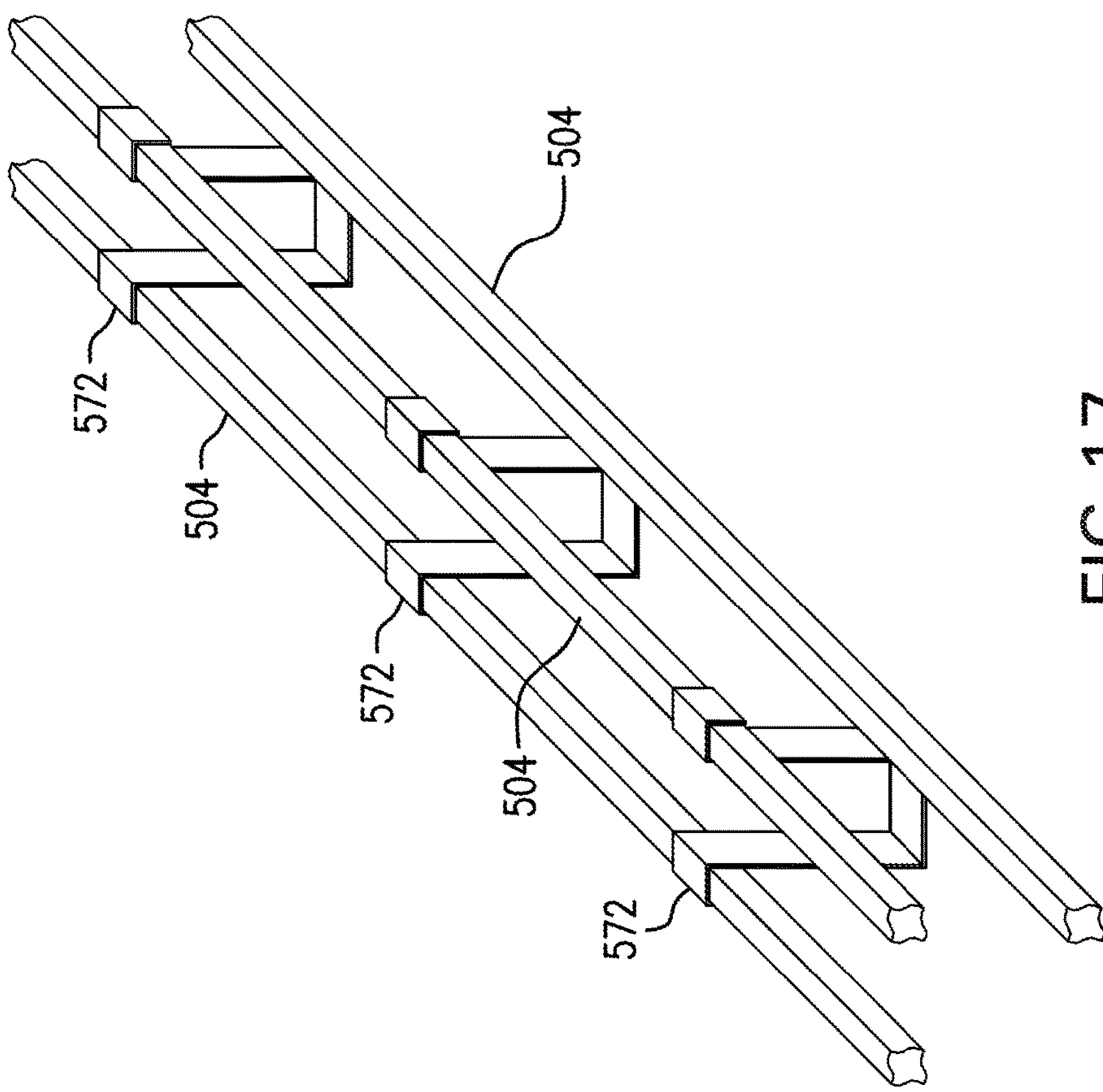

FIG. 17

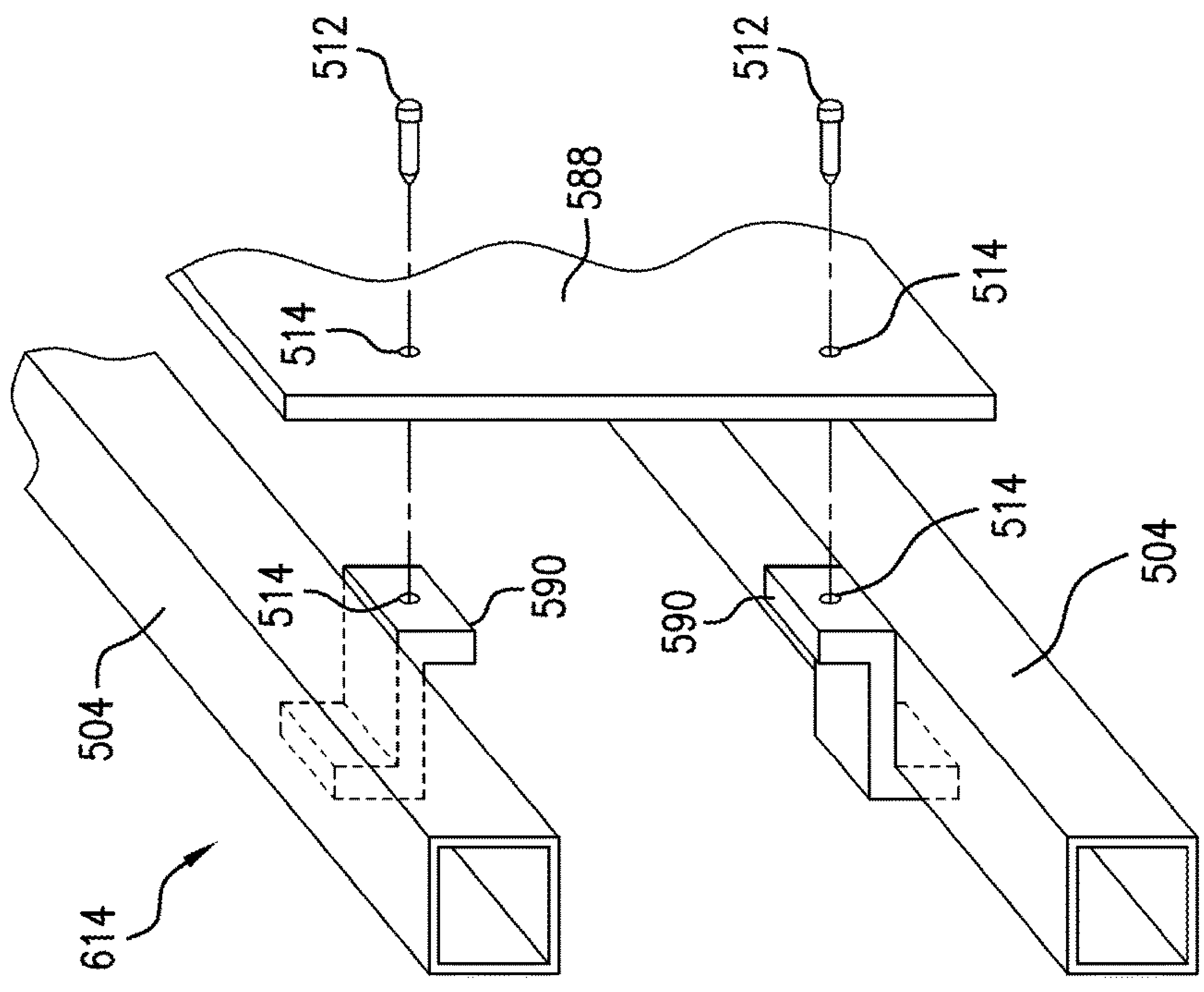
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FIG.18

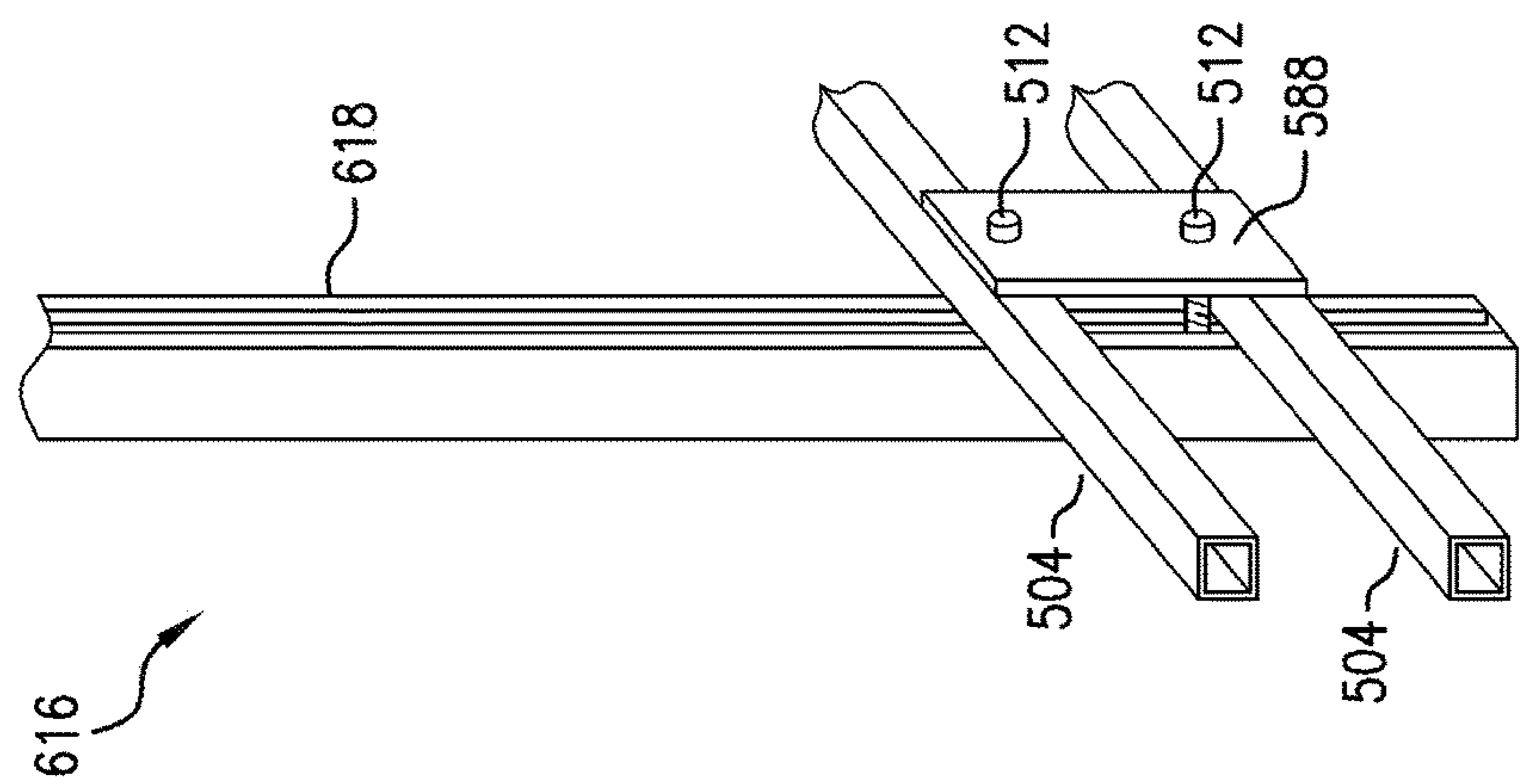
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FIG.19

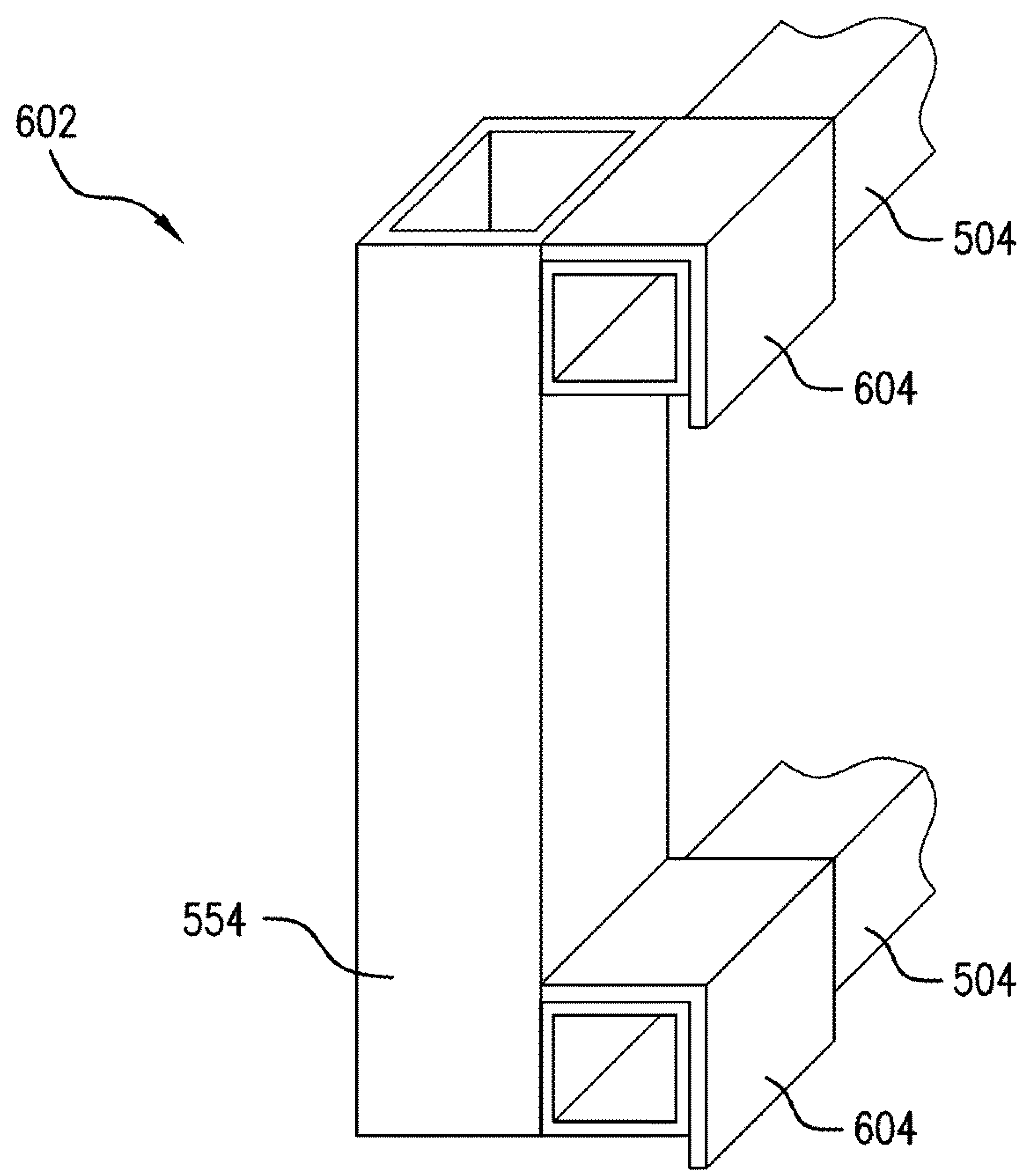

FIG.20

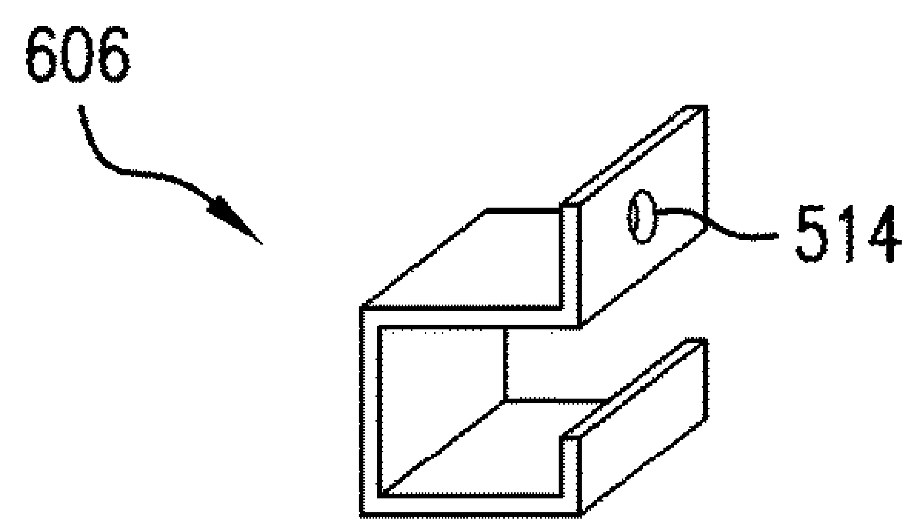

FIG.21A

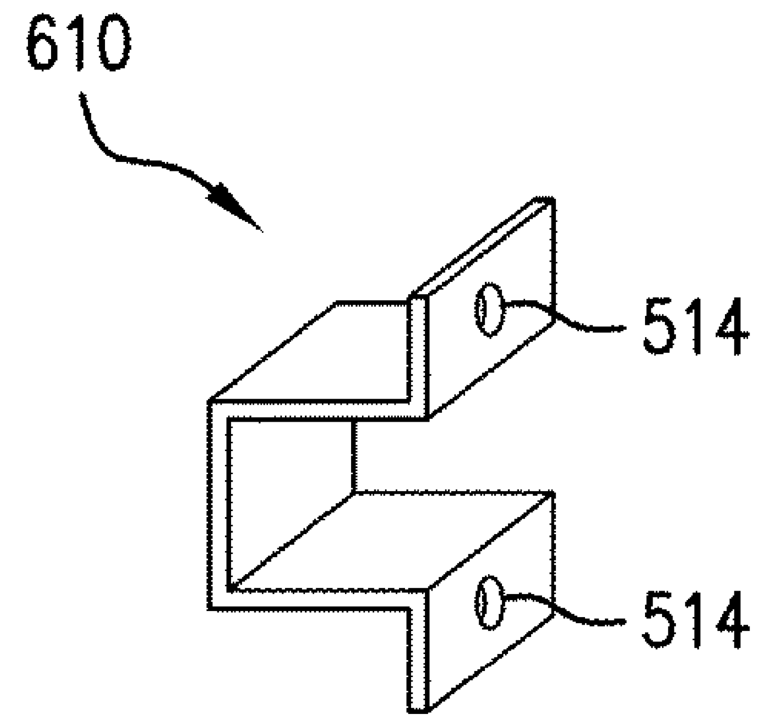

FIG.21B

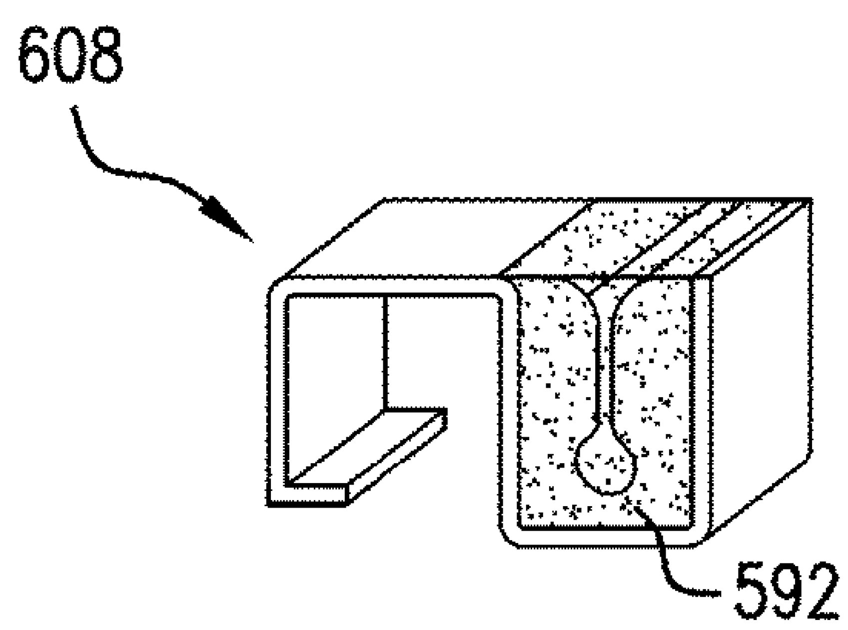

FIG.22A

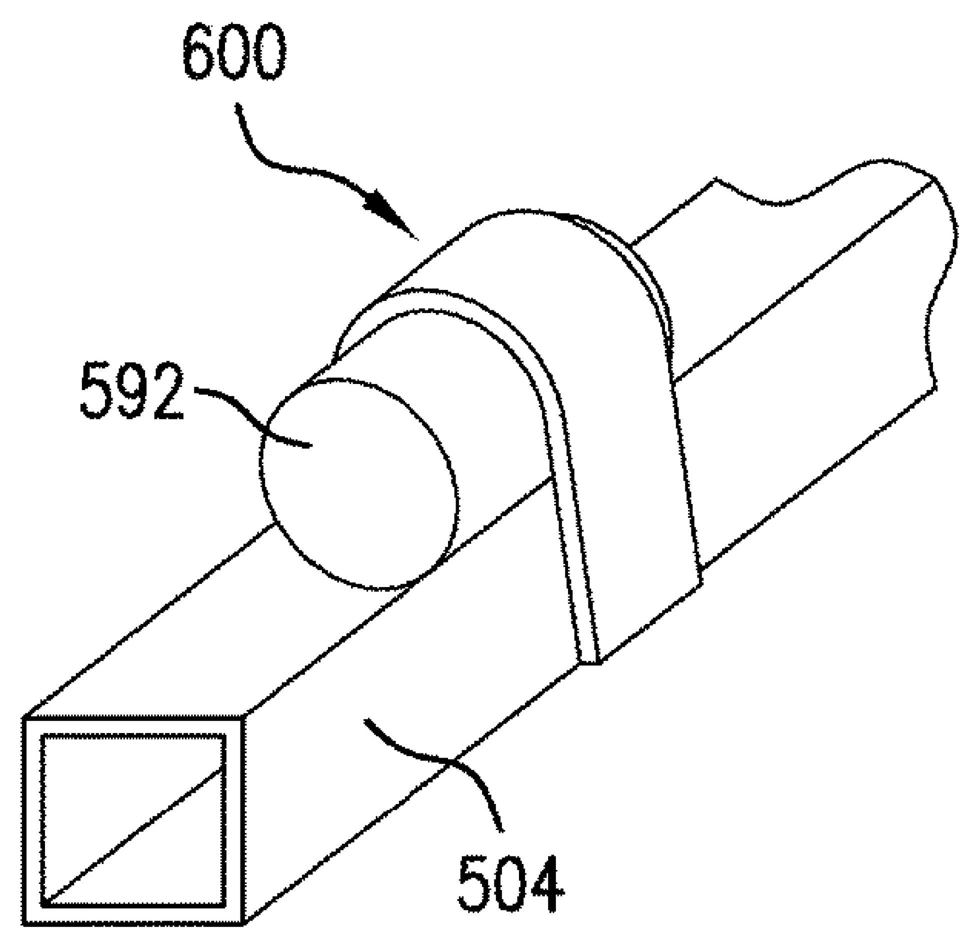

FIG.22B

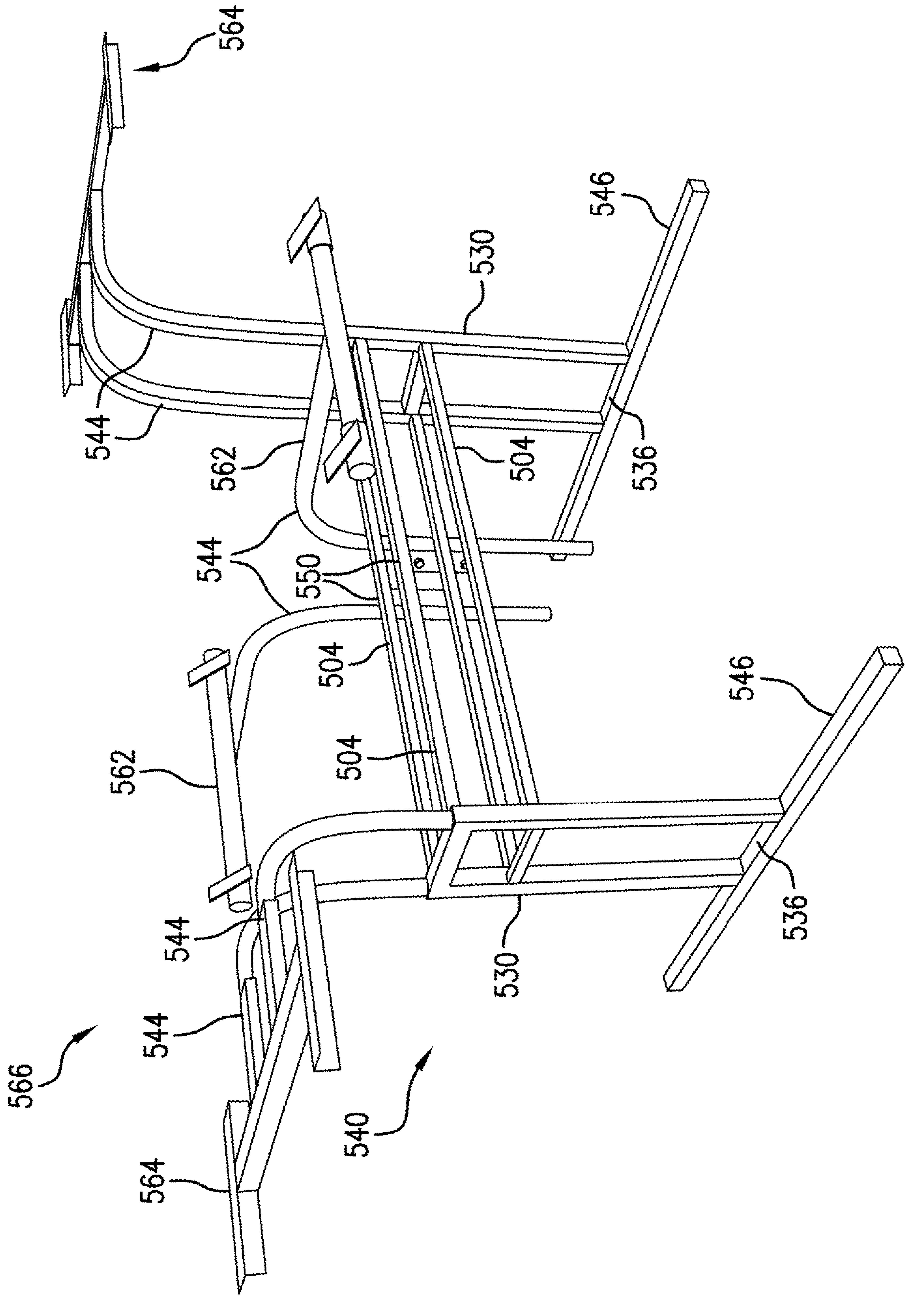
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FIG.23

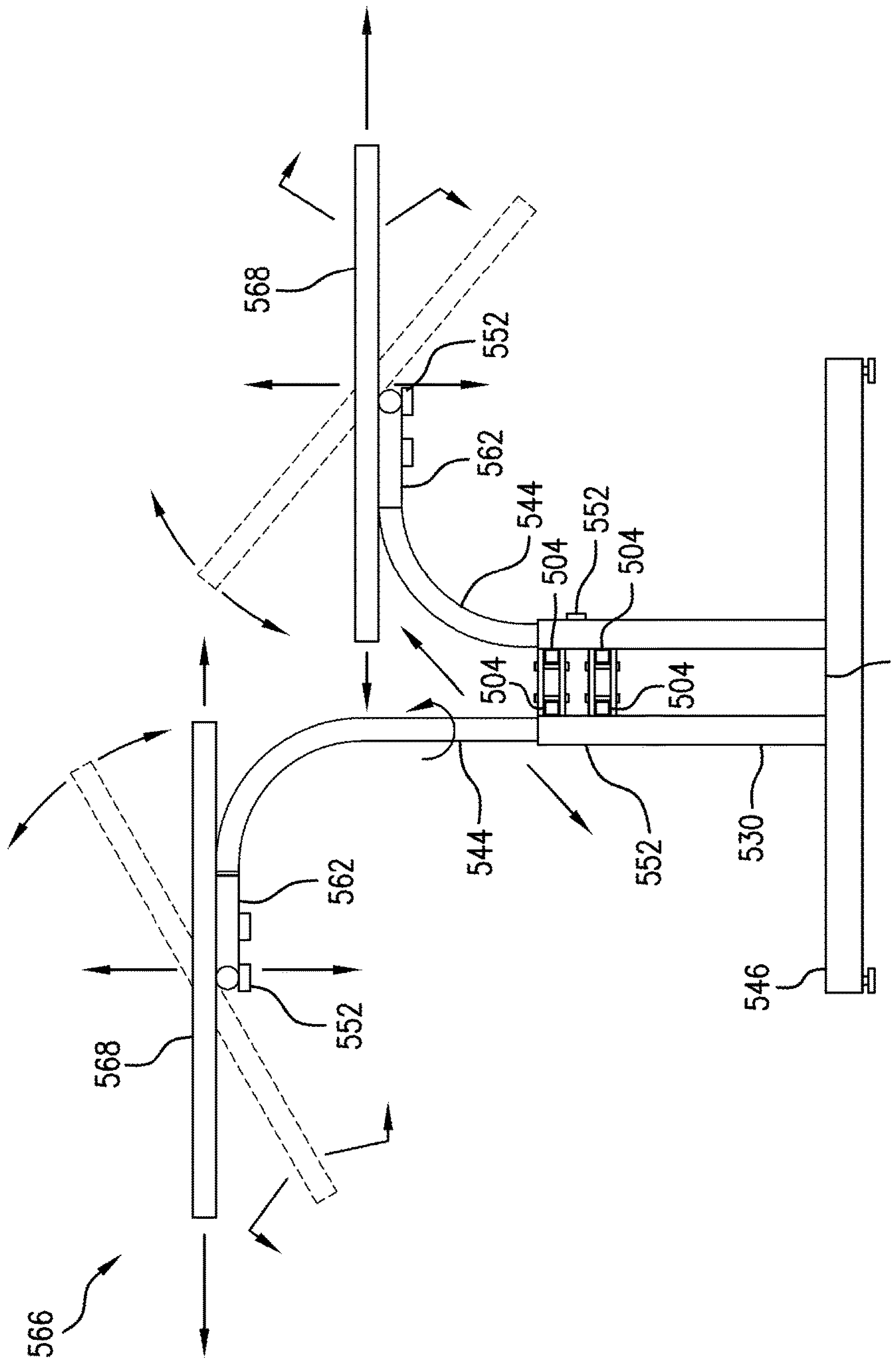
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FIG.24

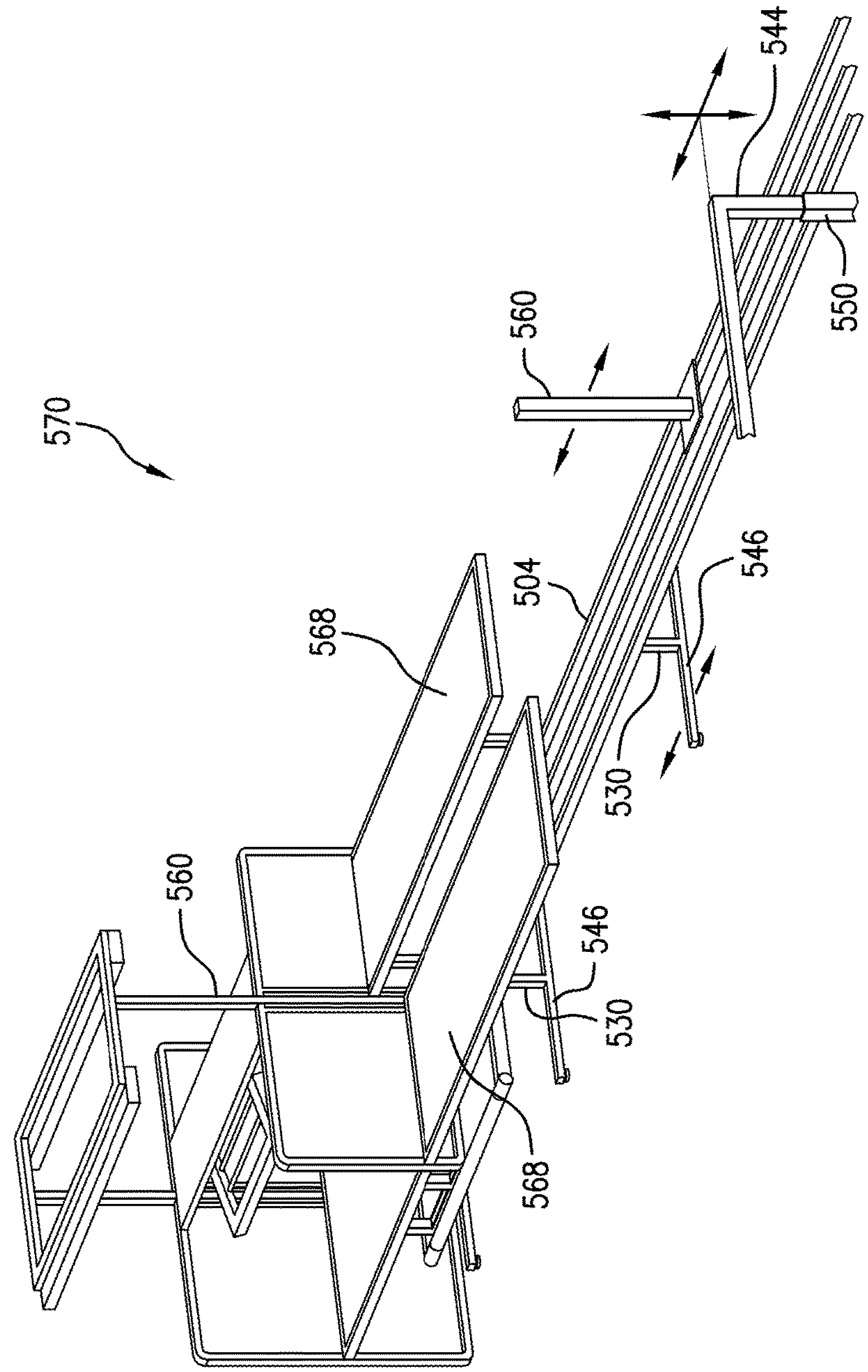


FIG.25

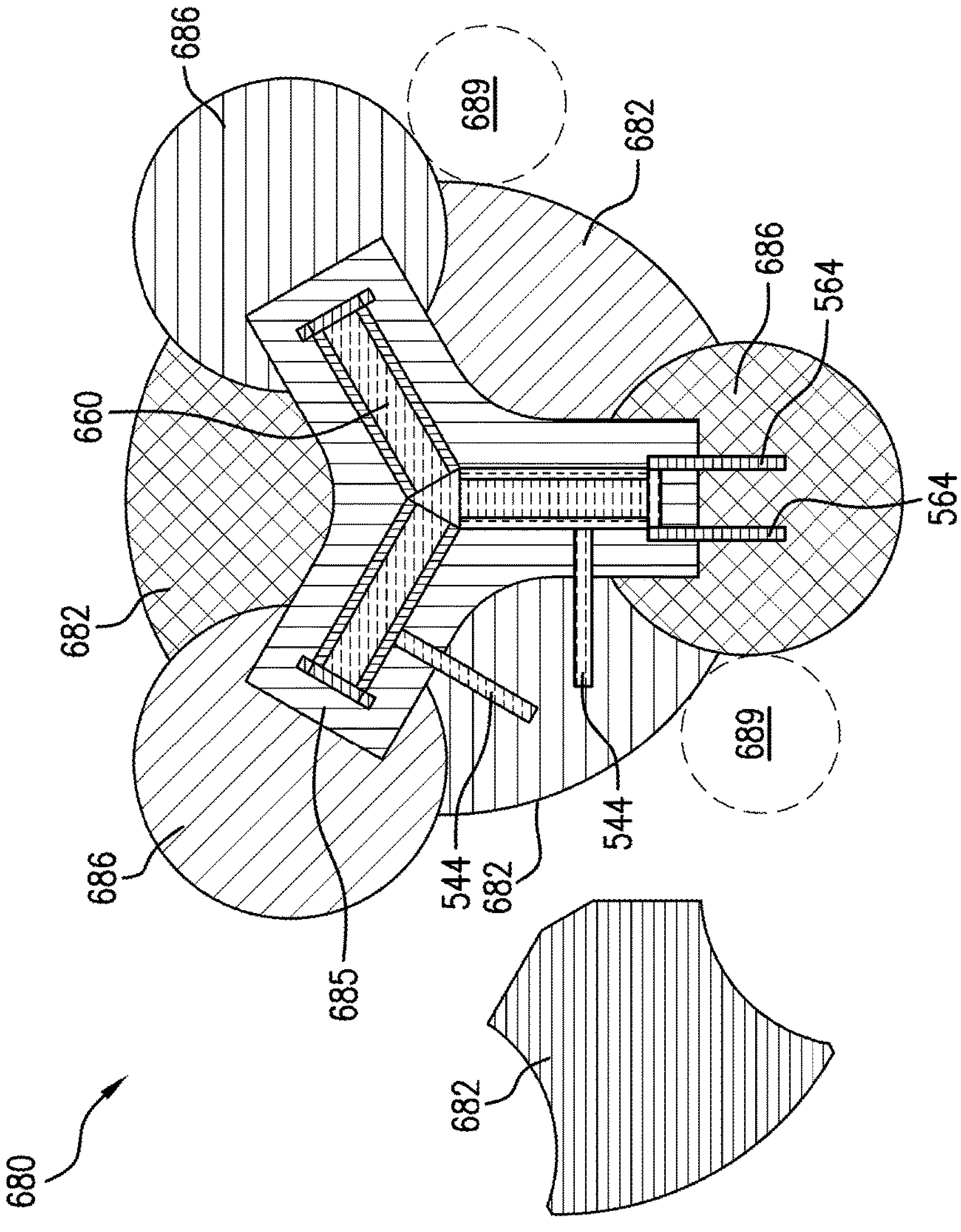
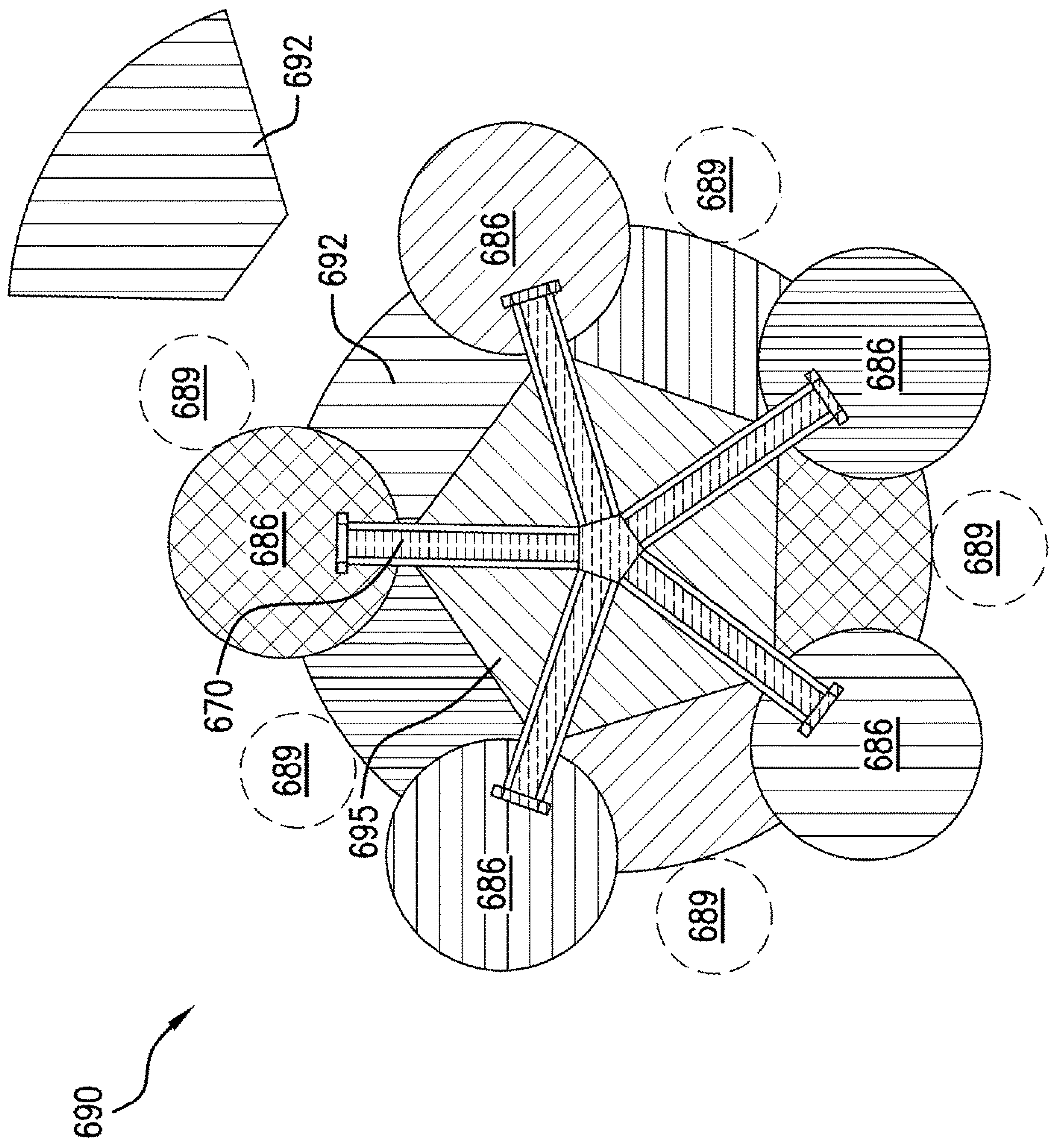


FIG.26



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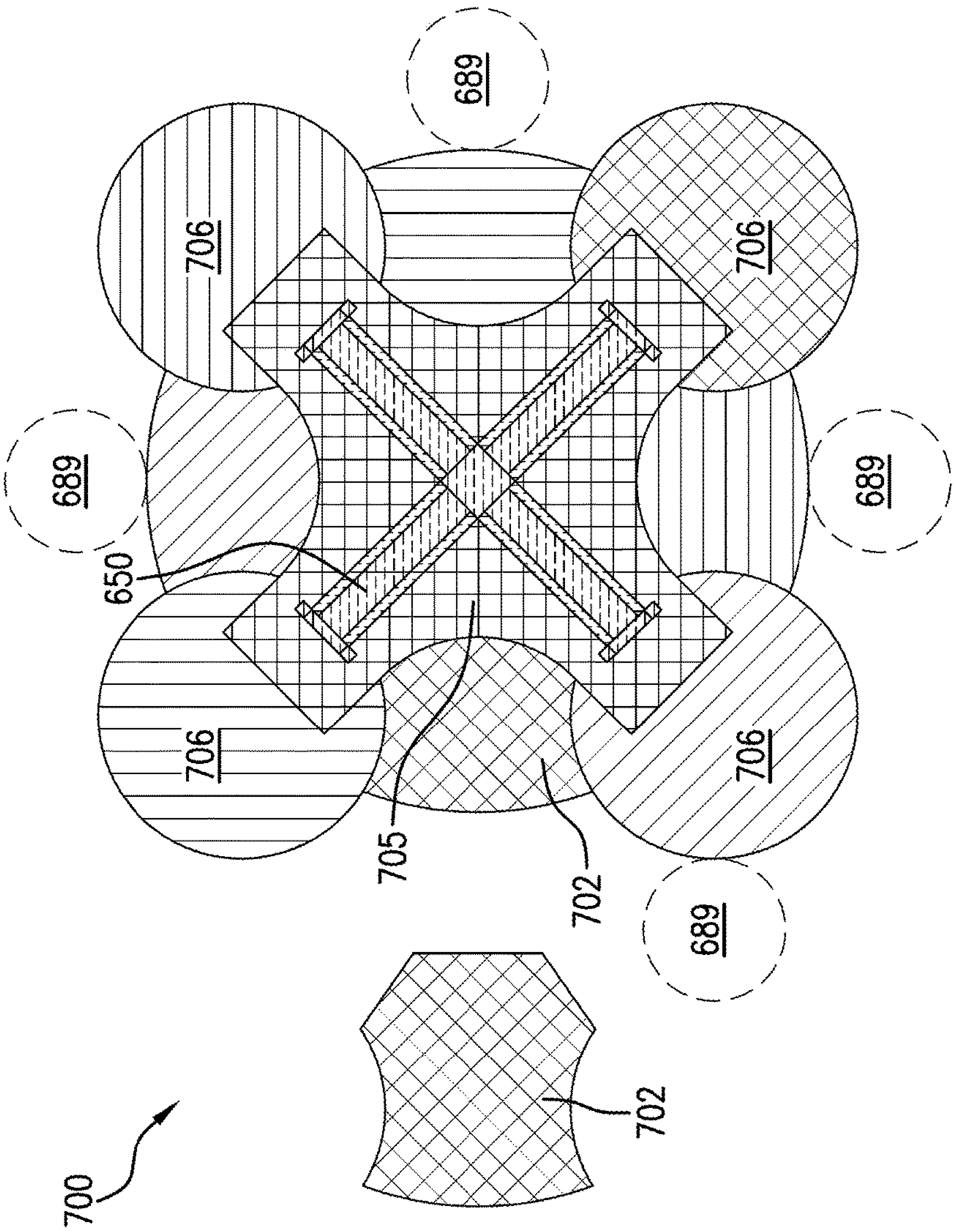

FIG.28

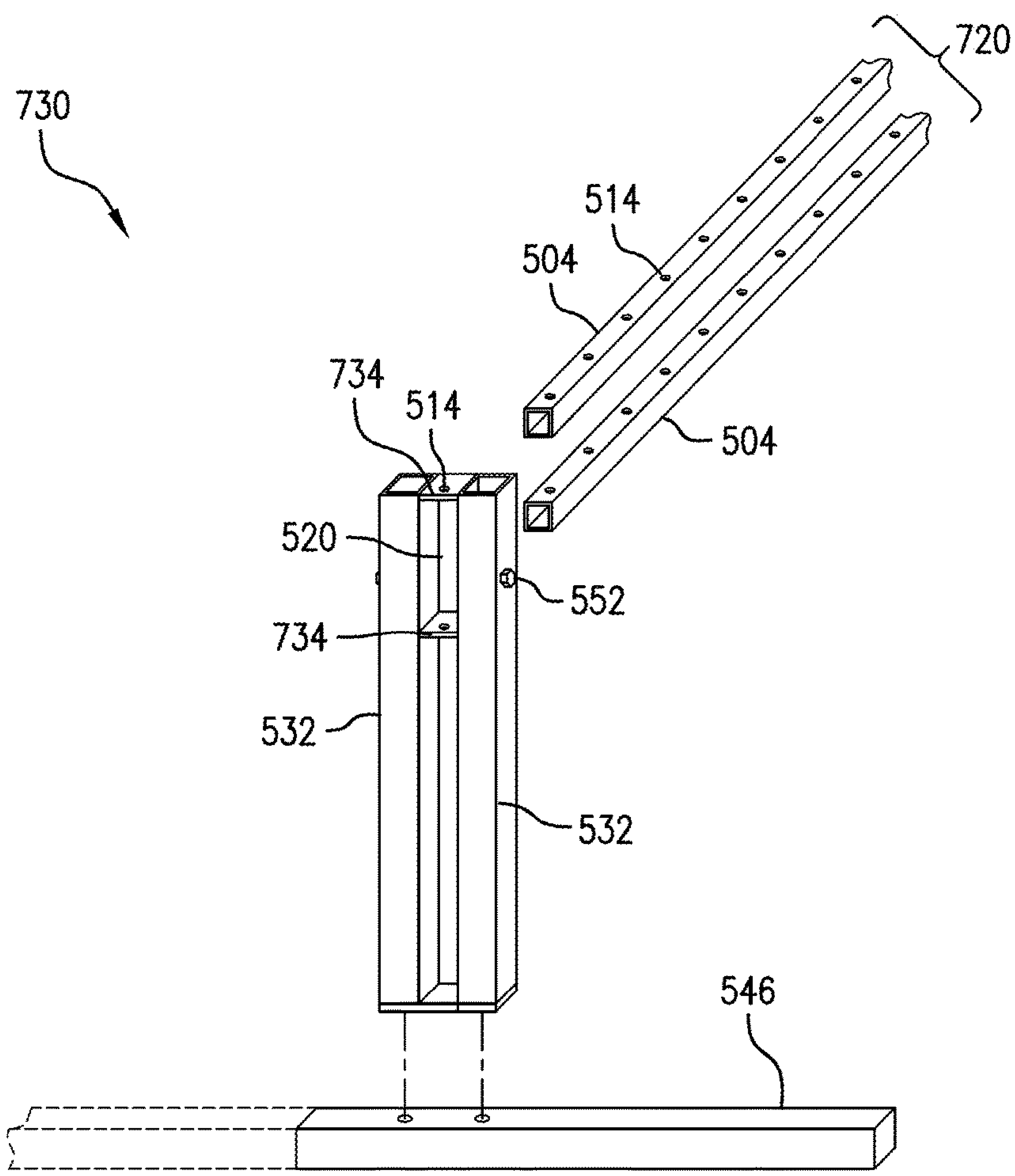

FIG.29

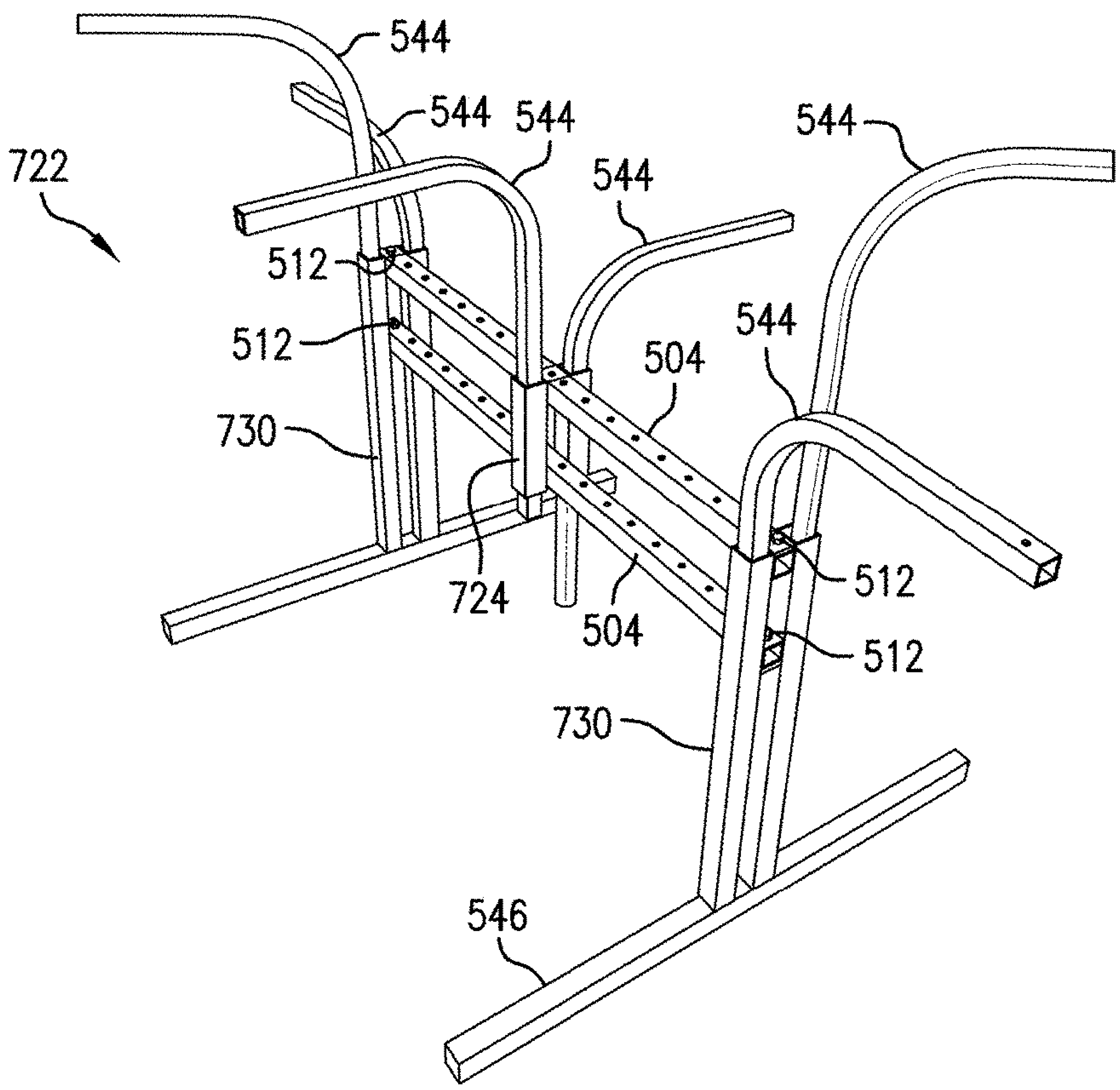
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FIG.30

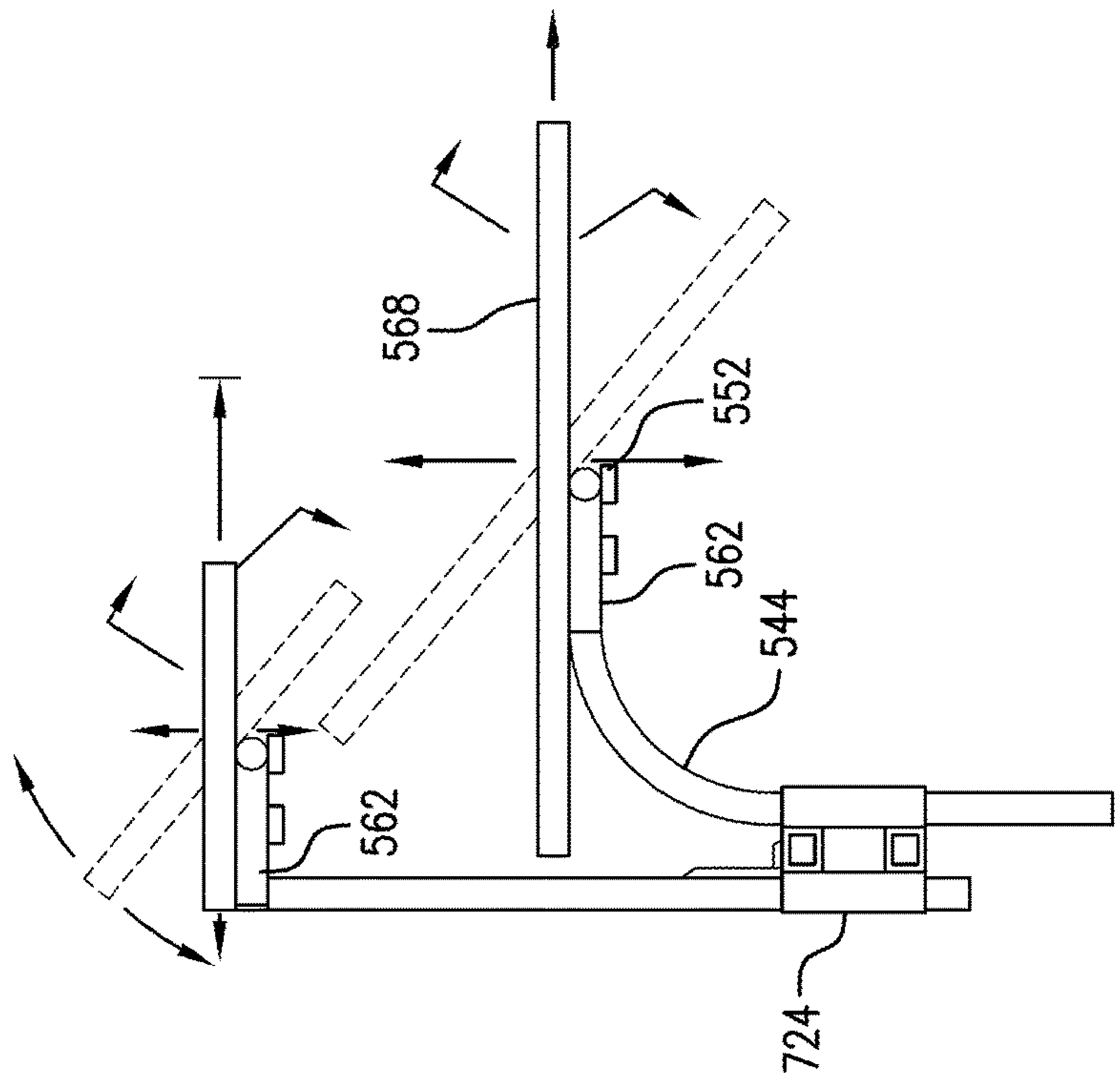
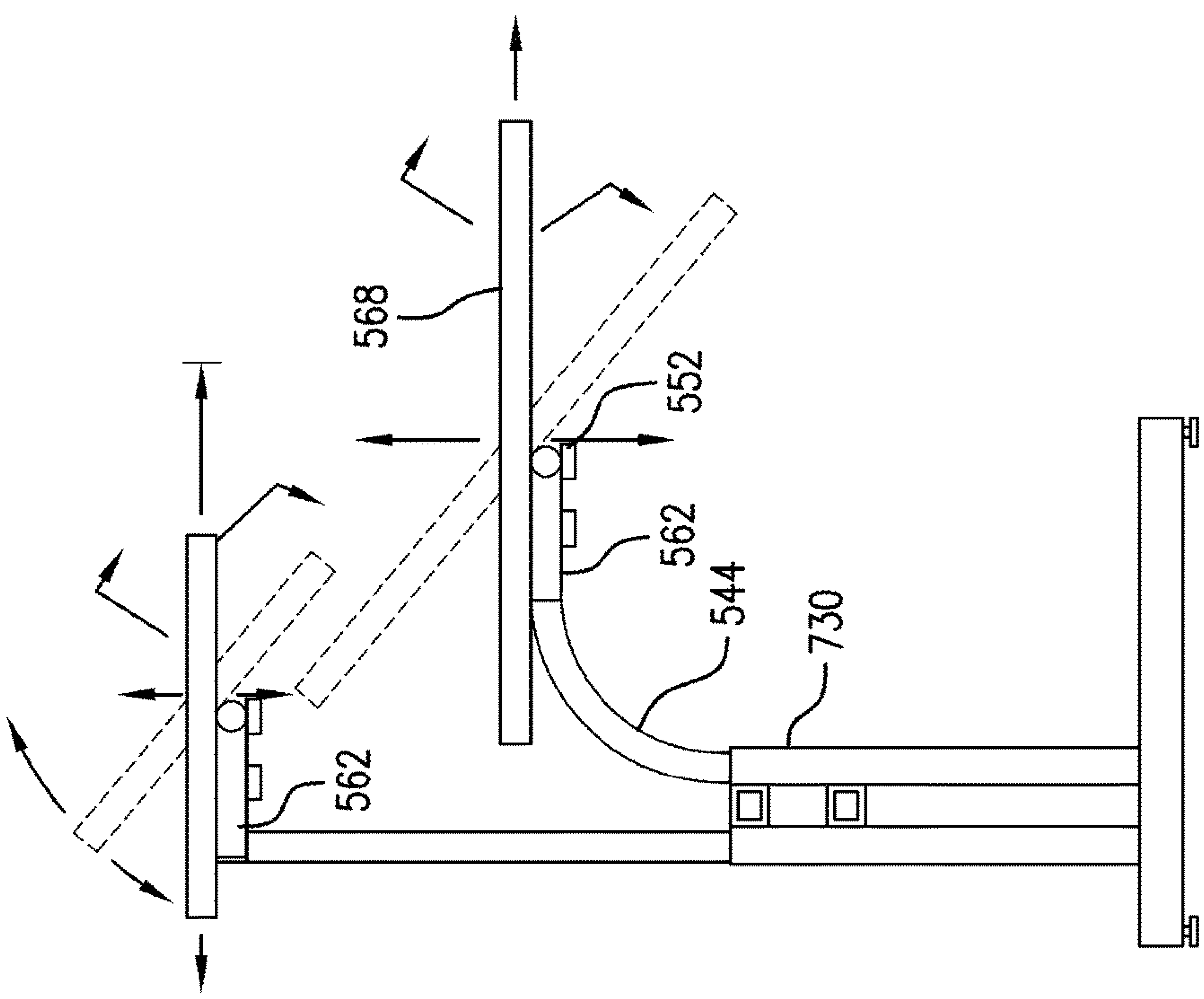


FIG.31B



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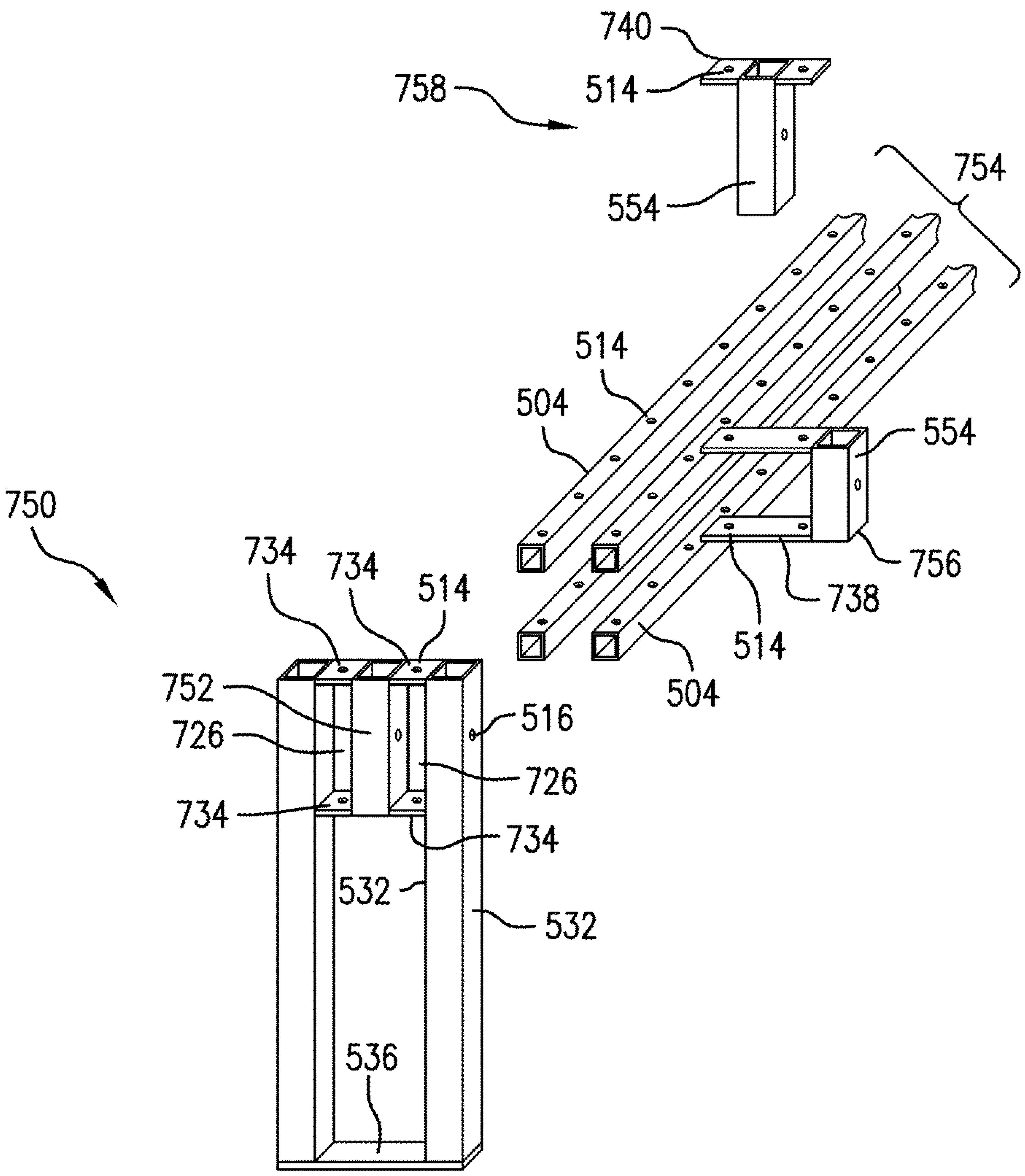

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FIG.32

THREE-DIMENSIONAL POSITIONING AND HOLDING MODULE SYSTEM FOR MODULAR WORKSTATIONS

CROSS-REFERENCE TO RELATED APPLICATION

The present application is a continuation-in-part application of application Ser. No. 15/466,609, filed 2017 Mar. 22, which is a continuation of application Ser. No. 15/080,506, filed 2016 Mar. 24, now U.S. Pat. No. 9,637,921, issued 2017 May 2, all incorporated herein by reference. This application also claims the benefit of U.S. Provisional Application No. 62/590,983, filed 2017 Nov. 27, incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to modular assembly systems. More particularly, the present invention relates to modular assembly systems for office and industrial work stations.

BACKGROUND

Modular building assembly systems have long been available to for the construction and erection of various structures such as office cubicles, industrial work stations, and scaffolding. Such modular building assembly systems usually have some type of standard beam that can be joined to other beams and to which various accessories can be attached. Solid bars, of circular or regular polygonal shape (such as square or hexagonal) may be used, but are inferior to tubes of the same shape because tubes have a better resistance to torsion for the same mass of material than do solid bars. Circular or regular polygons lack an easy point of attachment for accessories and other beams, so more complex shapes are preferred. One such complex shaped beam is a cruciform beam (see U.S. Pat. No. 5,481,842 to Gautreau, FIG. **1**). The cruciform beam comprises a center tube surrounded by four angle bars arranged in a square pattern in cross-section and each joined to the center tube with a web or fin, the fins forming a cross when the beam is viewed in cross-section. Accessories can be attached along the cruciform beam by clamping the accessory to one of the angle bars or in a longitudinal groove defined by the spaces between the fins and angle bars. The cruciform beam is relatively strong in resisting buckling when torsion is applied to the beam around an axis orthogonal to the long axis of the cruciform beam because in cross-section, a substantial amount of the beam material is distant from the center longitudinal axis. Such torsion occurs when the cruciform beam spans a space and a load is attached to the beam somewhere in the middle. However, the cruciform beam is not relatively strong when torsion is applied around the long axis of the cruciform beam. Such torsion occurs when a load is cantilevered from the side of the cruciform beam. Since a cruciform beam for a given size and weight does not have good resistance to torsion around its long axis, accessories are usually not cantilevered from the side of the cruciform beam.

What is needed is a modular building system with a beam that has strong resistance to torsion around its long axis.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated into and constitute a part of this specification, illustrate one or

more embodiments of the inventive subject matter and, together with the detailed description, serve to explain the principles and implementations thereof. Like reference numbers and characters are used to designate identical, corresponding, or similar components in different figures. The figures associated with this disclosure typically are not drawn with dimensional accuracy to scale, i.e., such drawings have been drafted with a focus on clarity of viewing and understanding rather than dimensional accuracy.

FIG. **1** shows a first representative embodiment of a quad-rail beam.

FIGS. **2**A and **2**B show a first embodiment of a rail-arm-leg (RAL) module.

FIG. **3** shows an exploded perspective view of an in-line splice.

FIG. **4** shows an exploded perspective view of two perpendicular rail splices.

FIG. **5** shows an exploded perspective view of a clip splice.

FIG. **6** shows a perspective view of a collar splice.

FIGS. **7**A and **7**B show a first embodiment of a workstation module.

FIG. **8** shows an overhead view of a second embodiment of a workstation module (I module).

FIG. **9**A shows an overhead view of a third embodiment of a workstation module (L module).

FIG. **9**B shows an overhead view of an alternative third embodiment of a workstation module (alternative L module).

FIG. **10**A shows an overhead view of a fourth embodiment of a workstation module (T module).

FIG. **10**B shows an overhead view of an alternative version of the fourth embodiment of a workstation module (alternative T module).

FIG. **11**A shows an overhead view of a fifth embodiment of a workstation module (X module).

FIG. **11**B shows an overhead view of an alternative version of the fifth embodiment workstation module (alternative X module).

FIG. **12** shows an overhead view of a sixth embodiment of a workstation module (Y module).

FIG. **13** shows a seventh embodiment of a workstation module ("pentagon" module).

FIG. **14** shows part of a first embodiment workstation module with arms attached and a rail support arm bracket.

FIGS. **15**A, **15**B, and **15**C respectively show top, front, and side views of a side mount clamp-on arm bracket.

FIG. **16** shows various brackets for use with the first representative embodiment quad-rail beam or first embodiment workstation module.

FIG. **17** shows quad rail cable cradles for use with the quad-rail beam or the workstation module.

FIG. **18** shows an S clip mounting.

FIG. **19** shows a channel-to-rail mounting.

FIG. **20** shows a single drop-on rail clip bracket.

FIG. **21**A shows a perspective view of a single rail single fastener clip.

FIG. **21**B show a perspective view of a single rail double fastener clip.

FIG. **22**A shows a perspective view of a single rail wire holding clip.

FIG. **22**B which shows a perspective view of a Velcro strip holding a service cable to a rail.

FIG. **23** shows a perspective view of a first representative workstation arrangement based on a first embodiment workstation module.

FIG. **24** shows a side view of the first representative workstation arrangement based on a first embodiment workstation module.

FIG. **25** shows a perspective view of a second representative workstation arrangement based on a first embodiment workstation module.

FIG. **26** shows a perspective view of a third embodiment workstation arrangement based on the sixth embodiment workstation module (Y module).

FIG. **27** shows a perspective view of a fourth embodiment workstation arrangement based on the seventh embodiment workstation module (pentagon module).

FIG. **28** shows a perspective view of a fifth embodiment workstation arrangement based on the fifth embodiment workstation module (X module).

FIG. **29** shows a representative embodiment of a twin rail-arm-leg module.

FIG. **30** shows a perspective view of a twin rail H module with a double drop-on rail clip bracket.

FIG. **31**A shows a side view of a twin rail H module with arms and work surfaces attached.

FIG. **31**B shows a side view of a double drop-on rail clip bracket with arms and work surfaces attached.

FIG. **32** shows a representative embodiment of a split quad rail-arm-leg module.

DETAILED DESCRIPTION

In describing the one or more representative embodiments of the inventive subject matter, use of directional terms such as "upper," "lower," "above," "below", "in front of" "behind," etc., unless otherwise stated, are intended to describe the positions and/or orientations of various components relative to one another as shown in the various Figures and are not intended to impose limitations on any position and/or orientation of any component relative to any reference point external to the Figures.

In the interest of clarity, not all of the routine features of representative embodiments of the inventive subject matter described herein are shown and described. It will, of course, be appreciated that in the development of any such actual implementation, numerous implementation-specific decisions must be made in order to achieve specific goals, such as compliance with application and business-related constraints, and that these specific goals will vary from one implementation to another and from one developer to another. Those skilled in the art will recognize that numerous modifications and changes may be made to the representative embodiment(s) without departing from the scope of the claims. It will, of course, be understood that modifications of the representative embodiments will be apparent to those skilled in the art, some being apparent only after study, others being matters of routine mechanical, chemical and electronic design. No single feature, function or property of the representative embodiments is essential. In addition to the embodiments described, other embodiments of the inventive subject matter are possible, their specific designs depending upon the particular application. As such, the scope of the inventive subject matter should not be limited by the particular embodiments herein described but should be defined only by the appended claims and equivalents thereof.

Three-Dimensional Positioning and Holding Modular System

The Three-Dimensional Positioning and Holding Modular System is a flexible system for building ergonomic working stations that maximizes three-dimensional utilization of a workspace. The Three-Dimensional Positioning and Holding Modular System comprises substructure modules and positioning holders. The substructure modules provide the foundation on which the positioning holders may be mounted. The positioning holders hold physical components needed for the work of the work station, such as table tops or other work surfaces, lighting fixtures, computer monitors, cable management, and storage bins.

Rails

A rail **504** in the Three-Dimensional Positioning and Holding Modular System is a tube, typically rectangular or square in cross section, but in alternative embodiments, may have a different cross-section, such as circular. (See FIG. **1**). A rail **504** may have zero, one or more fastener holes **514** to facilitate coupling to other rails **504**, to position holders, slices, etc. (See e.g. FIG. **3** and FIG. **4**). The fastener holes **514** typically penetrate through the rail **504** orthogonal to the long axis of the rail **504**. A rail **504** may have fastener holes **514** spaced at periodic intervals along the rail **504**, referred herein as a perforated rail. (See e.g. FIG. **29** and FIG. **32**). Perforated rails typically have fastener holes at 2 inch intervals. The fastener holes **514** in the rails **504** are typically unthreaded, but some may be threaded. A rail **504** is typically made of metal, such as steel, but may be made of other suitable materials. A rail **504** is typically 1¼ inch square cross-section, 14 gauge tube thickness. Length of perforated rails are typically 30 to 120 inches.

Quad-Rail Beam Module

One substructure module for use with the Three-Dimensional Positioning and Holding Modular System is a quad-rail beam **500**. FIG. **1** shows a representative embodiment of a quad-rail beam **500**. The quad-rail beam **500** comprises four rails **504** coupled by at least one peripheral binding structure such as the rail support bracket **508**, clamp plate **510** and fasteners **512** shown in FIG. **1**, which are configured to hold each of four rails **504** in a rectangular pattern.

The rail support bracket **508** is typically a rectangular tube, typically square in cross section, but in alternative embodiments, may have a different cross-section. The rail support bracket **508** has a bracket interior that conforms to the rectangular pattern. The rail support bracket **508** is typically used with at least one, or more typically, two clamp plates **510**. Each clamp plate **510** and one or more sides of the rail support bracket **508** each have at least one, or more typically, two fastener holes **514**. The fastener holes **514** are typically unthreaded, but in some embodiments may be threaded. Each clamp plate **510** is used to secure one, or more typically, two rails **504** to the rail support bracket **508**. Each clamp plate **510** is secured to the rail support bracket **508** with at least one fastener **512**, but two are typically used. Each fastener **512** passes through one of the fastener holes **514** in the rail support bracket **508** and a matching fastener hole **514** in the clamp plate **510**. Each fastener **512** and associated fastener holes **514** are positioned to hold an adjacent rail **504** between the fastener **512** and an adjacent side of the rail support bracket **508** with at least a sliding fit. However, the rails **504** are primarily held in place by friction induced by tension in the fasteners **512** drawing the clamp plate **510** and the rail support bracket **508** together. Therefore, in some embodiments, the fasteners **512** may not necessarily be adjacent and in sliding contact with the rails **504**.

The first exemplary embodiment quad-rail beam **500** is configured so that each of the four of rails **504** of the quad-rail beam **500** there is a gap that is at least as large as a largest cross-sectional dimension of one of the four rails. This is to ensure that the rails **504** are far enough apart to give the first exemplary embodiment quad-rail beam **500** good resistance to torsional twisting.

The quad-rail beam **500** has a cavity therein defined as an area between the inside corners of the four rails **504** and running a length of the four rails **504**. The cavity contains no load bearing structure connecting the rails that runs for more than a total of a half of the length of the rails. This arrangement makes efficient use of mass since structure in the cavity will have little resistance to torque induced twist.

Typically, each rail **504** has dimensions of 1 inch per side in cross-section, 14-gauge thickness and 40 inches long. The rail support bracket **508** has typical dimensions of 6 inches per side in the interior of the bracket. These dimensions provide 4 inch gaps between the rails **504**, which provides good resistance to twist induced by torque, and which also provides a convenient sized gap into which a typical worker can reach into and attach, detach or adjust accessory brackets and other attachments. However, in alternative embodiments, other dimensions of rails **504** and rail support brackets **508** may be used.

The quad-rail beam **500** has a structure that for its weight is highly resistant to twist induced by torque about its long axis (parallel to the rails **504**). For example, a torque is applied to the first representative embodiment quad-rail beam **500**, when a force is applied to one or more of the rails **504** in a direction that is orthogonal to the long axis of the quad-rail beam **500**, but does not pass through the long axis. The torque is transmitted along the rail **504** to the nearest rail support brackets **508**. The rail support brackets **508** transfer the torque to the other rails **504**. All the rails **504** and the rail support brackets **508** play a role in resisting the twist induced by the torque. Resistance to torque is proportional to the mass of an object times the distance of the mass from the torque axis. Most of the mass in the quad-rail beam **500** is fairly distant from its long axis, so for its mass, it offers a high degree of resistance to being twisted by torque. Resistance to twist from torque can be increased by adding additional rail support brackets **508** to the quad-rail beam **500** and/or decreasing the distance between them. Since each rail **504** is itself a tube, it also offers a high degree of resistance to twisting from torque induced by forces applied to the rail **504** in a direction that does not pass through the long axis of the rail **504**.

Open Quad Rail-Arm-Leg (RAL) Module

Another substructure for use with the Three-Dimensional Positioning and Holding Modular System is an open quad rail-arm-leg (RAL) module **530**. FIGS. **2**A and **2**B show a representative embodiment of an open quad rail-arm-leg module **530**. The open quad rail-arm-leg module **530** is named for what it is configured to have attached to it—rails, arms and legs. The open quad rail-arm-leg module **530** is part of a peripheral binding structure that also includes two clamp plates **510** and a plurality of fasteners **512** and is configured to hold each of four rails **504** in a rectangular pattern. The open quad rail-arm-leg module **530** comprises two columns **532** coupled by two cross plates **534** and a bottom plate **536**. The columns **532** are typically orthogonal from the cross plates **534** and the bottom plate **536**, with the two columns **532** arranged vertically in parallel and the two cross plates **534** and bottom plate **536** arranged horizontally in parallel. The columns **532** and the cross plates **534** define a module interior **520** that is open with a perimeter conforming to the rectangular pattern. The columns **532**, the cross plates **534**, and the bottom plate **536** are typically made of metal, such as steel, and coupled by welding, but may be made of other suitable materials and joined by other methods.

The columns **532** are hollow tubes with open top and bottom ends. In some embodiments, the bottom ends of the column **532** are closed off. Each column **532** has one or more threaded hole **516**, typically in the outside of the column **532**. The threaded hole **516** allows for insertion of a set screw to secure accessories inserted inside the column **532**. Each column **532** is typically rectangular in cross-section and may be square. In other embodiments, other suitable cross-sections, such as circular, may be used.

The open quad rail-arm-leg module **530** is typically used with at least one, or more typically, two clamp plates **510**. Each clamp plate **510** is typically the same size and shape as the cross plates **534**. The clamp plates **510** and the cross plates **534** have at least one, or more typically, two fastener holes **514**. The fastener holes **514** are typically unthreaded, but in some embodiments, may be threaded. Each clamp plate **510** is used to secure one, or more typically, two rails **504** to the open quad rail-arm-leg module **530**. Each clamp plate **510** is secured to one of the cross plates **534** with at least one fastener **512**, but two are typically used. Each fastener **512** passes through one of the fastener holes **514** in the cross plate **534** and a matching fastener hole **514** in the clamp plate **510**. Each fastener **512** and associated fastener holes **514** are positioned to hold an adjacent rail **504** between the fastener **512** and an adjacent column **532** with at least a sliding fit. However, the rails **504** are primarily held in place by friction induced by tension in the fasteners **512** drawing the clamp plate **510** and the rail support bracket **508** together. Therefore, in some embodiments, the fasteners **512** may not necessarily be adjacent and in sliding contact with the rails **504**.

The typical dimensions for the open quad rail-arm-leg module **530** are 20 inches high and 8½ inches wide across the front. The interior space of the open quad rail-arm-leg module **530** is typically 6 inches wide between the columns **532**, 6 inches between the two cross plates **534**, and 1½ inches deep. These dimensions are convenient for building industrial workstations, but other dimensions may be used. The cross plate **534** nearest the top of the open quad rail-arm-leg module **530** is typically flush with the top of the columns **532**, but in some embodiments, may be positioned lower.

Rail Splices

Rail splices are used to couple two or more rails **504**. At least three different rail splices may be used in the Three-Dimensional Positioning and Holding Modular System—an in-line splice **624**, a perpendicular rail splice **628**, and a clip splice **634**.

FIG. **3** shows an exploded perspective view of an in-line splice **624** connecting two rails **504** that are in-line which each other and abut each other. The in-line rail splice **624** comprises two fasteners **512** and a nut plate **626** with a first fastener hole **514** and a second fastener hole **514**. When coupling the two rails **504**, the first fastener hole **514** is configured to line up with a fastener hole **514** in one rail **504** through which one of the fasteners **512** is passed. The second fastener hole **514** is configured to line up with a fastener hole **514** in the other rail **504** through which the other fastener

512 is passed. The fastener 512 may be a rivet, a threaded cap screw and nut or other appropriate type of fastener. The fastener holes 514 are typically unthreaded but may be threaded. In some embodiments, each in-line rail splice 624 has two nut plates 626, one above the rails 504 and the other below.

FIG. 4 shows an exploded perspective view of two perpendicular rail splices 628 connecting a single rail 504 to a pair of parallel rails 504 that are parallel to each other and perpendicular to the single rail 504. Each perpendicular rail splice 628 comprises two fasteners 512 and a nut plate 626 with a first fastener hole 514 and a second fastener hole 514. When coupling the single rail 504 to the set of parallel rails, the first fastener hole 514 is configured to line up with a fastener hole 514 in the single rail 504 through which one of the fasteners 512 is passed. The second fastener hole 514 is configured to line up with a fastener hole 514 in one of the rails 504 in the parallel set of rails 504 through which the other fastener 512 is passed. The fastener 512 may be a rivet, a threaded cap screw and nut or other appropriate type of fastener. The fastener holes 514 are typically unthreaded but may be threaded. In some embodiments, each perpendicular rail splice 628 has two nut plates 626, one above the rails 504 and the other below.

FIG. 5 shows an exploded perspective view of a clip splice 634. The clip splice 634 connects a single rail 504 to a set of parallel rails 504 that are parallel to each other and perpendicular to the single rail 504. The clip splice 634 comprises a double-rail-to-single-rail clip 622 having a cross-sectional with three sides of a rectangle that allows the single rail 504 to nest therein with a sliding fit. The parallel rails 504 have fastener holes 514 near the ends closest to the double-rail-to-single-rail clip 622, which has two fastener holes 514 in a lip that overhangs the single bar 504 when the single rail 504 is nested within the double-rail-to-single-rail clip 622. With the double-rail-to-single-rail clip 622 clipped on to the single rail 504, two fasteners 512, such as a threaded screws, rivets or other fastening mechanisms pass through the two fastener holes 514 of the double-rail-to-single-rail clip 622 and the parallel rails 504, securing the parallel rails 504 to the single rail 504. The double-rail-to-single-rail clip 622 allows the parallel rails 504 to slide laterally relative to the single rail 504. In some embodiments, the clip splice 634 has a threaded hole 516 with a set screw 552 inserted therein. The set screw 552 can be tightened to engage the rail 504, holding the clip splice 634 in place on the single rail 504, or loosened to disengage from the single rail 504, allowing the clip splice 634 to slide along the single rail 504.

FIG. 6 shows a perspective view of a collar splice 636. The collar splice 636 is used to connect a first set of four rails 504 to a second set of four rails 504. The collar splice 636 is similar to the rail support bracket 508, but the fasteners 512 are in different places and the collar splice 636 has additional fasteners 512. Positioned near each corner of the collar splice 636 are two fastener holes 514. Fasteners 512 of the collar splice 636 pass through fastener holes 514 in the rail support bracket 508 and through fastener holes (not shown) in the ends of the first and second set of rails 504 and through a clamp plate 510. The fastener 512 may be a rivet, a threaded cap screw and nut or other appropriate type of fastener. The fastener holes 514 are typically unthreaded but may be threaded.

First Embodiment Workstation Module (H Module)

FIGS. 7A and 7B show a first embodiment of a workstation module 540, also referred herein as an H module. The H module 540 comprises two quad rail-arm-leg modules 530 and four rails 504. The rails 504 are secured to the quad rail-arm-leg modules 530 with cross plates 534 and fasteners 512 as described elsewhere herein. While the H module 540 may be freestanding without them, typically it has one or more sets of horizontal legs 546 to give it greater stability. The sets of horizontal legs 546 are coupled to the bottom of the open quad rail-arm-leg module 530. Typically, the horizontal legs 546 extend out horizontally to either side of the open quad rail-arm-leg module 530. The set of horizontal legs 546 typically has two vertical posts that are positioned and sized to slidingly insert into the bottom openings of the columns 532 of an open quad rail-arm-leg module 530, held in place by gravity, a set screw, or some other suitable mechanism. In other embodiments, the set of horizontal legs 546 is more permanently coupled to the open quad rail-arm-leg module 530 by welding, fasteners or other suitable mechanism.

The H module 540 has a cavity therein defined as an area between the inside corners of the four rails 504 and running a length of the four rails 504. The cavity contains no load bearing structure connecting the rails that runs for more than a total of a half of the length of the rails. This arrangement makes efficient use of mass since structure in the cavity will have little resistance to torque induced twist.

Second Embodiment Workstation Module (I Module)

FIG. 8 shows an overhead view of a second embodiment of a workstation module 620 referred herein as an "I" module. The I module 620 comprises two quad rail-arm-leg modules 530 connected by set of four rails 504. It is similar to the H module 540, but without the horizontal legs 546. Without the horizontal leg 546, I module 540 does not have as much inherent stability, but is useful in situations where stability is provided by other means, such as by attaching the quad rail-arm-leg modules 530 of the I module 620 to a floor by bolts or other attachment mechanisms.

Third Embodiment Workstation Module (L Module)

FIG. 9A shows an overhead view of a third embodiment of a workstation module 630 referred herein as an "L" module. The L module 630 comprises an I module 620 coupled with a truncated I module 612. The I module 620 portion of the L module 630 comprises two quad rail-arm-leg modules 530 connected by first set of four rails 504 The truncated I module 612 portion of the L module 630 comprises an open quad rail-arm-leg module 530 connected to a second set of rails 504 (typically four), essentially an I module 620 with one open quad rail-arm-leg module 530 removed. The rails 504 of the truncated I module 612 portion are connected to the rails 504 of the I module 620 portion by a plurality of perpendicular nut plate splices 628 such that the one of the rails 504 of the truncated I module 612 is adjacent or in contact with the one of the quad rail-arm-leg modules 530 of the I module 620 portion. Typically, two upper rails 504 of the truncated I module 612 are coupled to one of two upper rails 504 of the I module portion 620 and lower rails 504 of the truncated I module 612 are coupled to one of two lower rails 504 of the I module 620 directly below the upper rail 504 that is coupled to the truncated I module 612.

FIG. 9B shows an overhead view of an alternative version of the third embodiment of a workstation module 632 (alternative L module). In the alternative L module **632**, the second set of rails (part of the truncated I module **612**) is connected to the first set of rails **504** (part of the I module **620**) by one or more clip splices **634** (typically two) instead of the plurality of perpendicular nut plate splices **628**. The clip splice **634** may slide along the first set of rails **504** of the I module **620** portion of the L module **630**.

Fourth Embodiment Workstation Module (T Module)

FIG. **10**A shows an overhead view of a fourth embodiment of a workstation module **640** referred herein as a "T" module. The T module **640** is similar to the L module **630**, but the second set of rails **504** (part of the truncated I module **612**) are connected at or near the middle of the first set of rails **504** (part of the I module **620**). In the T module **640**, the second set of rails is coupled to the first set of rails with a plurality of perpendicular nut plate splices **628**, typically four, one for each of the four rails **504** in the second set of rails **504**.

FIG. **10**B shows an overhead view of an alternative version of the fourth embodiment of a workstation module **642** (alternative T module). In the alternative T module **642**, the second set of rails **504** (part of the truncated I module **612**) is connected to the first set of rails **504** (part of the I module **620**) by one or more double-rail-to-single-rail clips **622** (typically two) instead of the plurality of perpendicular nut plate splices **628**. The double-rail-to-single-rail clips **622** may slide along the first set of rails **504**.

Fifth Embodiment Workstation Module (X Module)

FIG. **11**A shows an overhead view of a fifth embodiment of a workstation module **650** referred herein as an "X" module. The X module **650** is similar to the T module **640**, but has a third set of rails **504** (part of a second truncated I module **612**) that are connected to the first set of rails **504** (part of the I module **620**) at or near the middle of the first set of rails **504** opposite the second set of rails **504**. In the fifth embodiment workstation module **650**, the third set of rails is coupled to the first set of rails with a plurality of perpendicular nut plate splices **628**, typically four, one for each of the four rail **504***s* in the third set of rails **504**.

FIG. **11**B shows an overhead view of an alternative version of the fifth embodiment workstation module **652** (alternative X module). In the alternative X module **652**, the third set of rails **504** (part of a second truncated I module **612**) is connected to the first set of rails **504** (part of the I module **620**) by one or more double-rail-to-single-rail clips **622** (typically two) instead of the plurality of perpendicular nut plate splices **628**. The double-rail-to-single-rail clips **622** may slide along the first set of rails **504**.

Sixth Embodiment Workstation Module (Y Module)

FIG. **12** shows an overhead view of a sixth embodiment of a workstation module **660** referred herein as a "Y" module. The Y module **660** comprises three truncated I modules **612** coupled to two Y module center couplers **662**. Each Y module center couplers **662** comprises three rails **504** coupled together, typically by welding, but in some embodiments by threaded fasteners or other suitable coupling mechanism. In some embodiments, the three rails **504** of the Y module center coupler **662** are forged as a single monolithic piece. The rails **504** of the truncated I modules **612** couple to the Y module center couplers **662** with perpendicular nut plate splices **628** or clip splices **634**.

Seventh Embodiment Workstation Module (Pentagon Module)

FIG. **13** shows a seventh embodiment of a workstation module **670** referred herein as a "pentagon" module. The pentagon module **670** comprises five truncated I modules **612** coupled to two pentagon module center couplers **672**. Each pentagon module center coupler **672** comprises five rails **504** coupled together, typically by welding, but in some embodiments by threaded fasteners or other suitable coupling mechanism. In some embodiments, the five rails **504** of the pentagon module center coupler **672** are forged as a single monolithic piece. The rails **504** of the truncated I modules **612** couple to the pentagon module center coupler **672** with perpendicular nut plate splices **628** or clip splices **634**.

Twin Rail-Arm-Leg (RAL) Module

Another substructure for use with the Three-Dimensional Positioning and Holding Modular System is a twin rail-arm-leg (RAL) module **730**. FIG. **29** shows a representative embodiment of a twin rail-arm-leg module **730**. The twin rail-arm-leg module **730** is similar to the open quad rail-arm-leg module **530**, but is configured to hold two rails **504**, one above the other to form a twin rail beam **720**, rather than four rails **504** in a rectangular pattern forming a quad-rail beam **500**. The twin rail-arm-leg module **730** comprises two columns **532** coupled by two cross plates **734** and a bottom plate **736**. The columns **532** are orthogonal from the cross plates **734** and the bottom plate **736**, with the two columns **532** arranged vertically in parallel. The two cross plates **734** and the bottom plate **736** are arranged horizontally in parallel. The columns **732** and the cross plates **734** define a module interior configured for receiving the two rails **504**. In the representative embodiment, the module interior is slightly wider than a rail **504**, providing a sliding fit, but in other embodiments, the module interior may be wider and a looser fit may be provided. The columns **532**, the cross plates **734**, and the bottom plate **736** are typically made of metal, such as steel, and coupled by welding, but may be made of other suitable materials and joined by other methods. The columns **532** in the twin rail-arm-leg module **730** are essentially identical to the columns **532** in the open quad rail-arm-leg module **530**. The two cross plates **734** each have a fastener hole **514**. The fastener holes **514** are typically unthreaded, but in some embodiments, may be threaded.

The rails **504** for use with the twin rail-arm-leg module **730** have fastener holes **514** spaced at periodic distances along the rail **504**. The fastener holes **514** in the rails **504** are typically unthreaded, but in some embodiments, may be threaded.

The twin rail-arm-leg module **730** is configured to combine with the rails **504** to make work stations of various configurations. The twin rail-arm-leg module **730** is configured for two rails **504** to be inserted into the interior space of the twin rail-arm-leg module **730**. One rail **504** is attached to the underside of the upper cross plate **734** with a fastener passing through the fastener holes **514** in the rail **504** and the upper cross plate **734**. The other rail **504** is attached to the topside of the lower cross plate **734** with a fastener passing through the fastener holes **514** in the rail **504** and the lower cross plate **734**.

While not having as much resistance to torque induced twist as the open quad rail-arm-leg module **530**, the twin rail beam **720** still provides a good amount of torque resistance due to the space between the rails **504**. The twin rail beam **720** is configured so that between the two rails there is a gap that is at least as large as a largest cross-sectional dimension of one of the two rails. This is to ensure that the rails **504** are far enough apart to give the twin rail beam **720** good resistance to torsional twisting.

The typical dimensions for the twin rail-arm-leg module **730** are 20 inches high and 3¾ inches wide across the front. The interior space of the twin rail-arm-leg module **730** is typically 1¼ inches wide between the columns **532**, 6 inches between the two cross plates **534**, and 1½ inches deep. These dimensions are convenient for building industrial workstations, but other dimensions may be used. The cross plate **734** nearest the top of the twin rail-arm-leg module **730** is typically flush with the top of the columns **532**, but in some embodiments, may be positioned lower. The fastener holes **514** are ⅜-inch diameter and on the rail **504** have 2 inch spacing.

While twin rail-arm-leg module **730** may be freestanding, typically it has one or more horizontal legs **546** to give it greater stability. The horizontal legs **546** are coupled to the bottom of the twin rail-arm-leg module **730** by welding, fasteners or other suitable mechanism.

The twin rail-arm-leg module **730** may be used to make any of workstation embodiments based on the open quad rail-arm-leg module **530** described herein, the necessary changes being made, including the H module **540**, the I module **620**, the L module **630**, the T module **640**, the X module **650**, the Y module **660**, and the pentagon module **670**. FIG. **30** shows a twin rail H module **722** with a double drop-on rail clip bracket **724** clipped on to the rails **504** of the twin rail H module **722**. FIG. **31**A shows a side view of a twin rail H module with arms **544**, single-arm table support bracket **562**, and table tops **568** attached. FIG. **31**B shows a side view of a double drop-on rail clip bracket **724** with arms **544**, single-arm table support bracket **562**, and table tops **568** attached.

Split Quad Rail-Arm-Leg (RAL) Module

Another substructure for use with the Three-Dimensional Positioning and Holding Modular System is a split quad rail-arm-leg module **750**. FIG. **32** shows a representative embodiment of a split quad rail-arm-leg module **750**. The split quad rail-arm-leg module **750** is similar to the open quad rail-arm-leg module **530**, but the module interior is split by a center column **752**. The split quad rail-arm-leg module **750** comprises two columns **532** on either side coupled a bottom plate **736**. Two cross plates **734**, an upper and a lower, couple one of the columns **532** to the center column **752** and two more cross plates **734** couple the other column **532** to the center column **752**. The columns **532** are orthogonal from the cross plates **734** and the bottom plate **736**, with the two columns **532** on the sides and the center column **752** arranged vertically in parallel. The two cross plates **734** and the bottom plate **736** are arranged horizontally in parallel. The center column **752** has an open top and is similar in construction to the columns **732** on the sides of the split quad rail-arm-leg module **750**. The center column **752** extends between the cross plates **734** in the exemplary embodiment, but in other embodiments, may extend to the bottom plate **736**. The columns **732** and the cross plates **734** define a module interior **520** divided in two partial module interiors **726** by the center column **752** with each partial module interior **726** configured for receiving two rails **504**. In the representative embodiment, each partial module interior **726** is slightly wider than a rail **504**, providing a sliding fit between the column **532** and the center column **752**, but in other embodiments, each partial module interior **726** may be wider and a looser fit may be provided. The columns **532**, the cross plates **734**, and the bottom plate **736** are typically made of metal, such as steel, and coupled by welding, but may be made of other suitable materials and joined by other methods. The columns **532** in the split quad rail-arm-leg module **750** are essentially identical to the columns **532** in the open quad rail-arm-leg module **530**. The four cross plates **734** each have a fastener hole **514**. The fastener holes **514** are typically unthreaded, but in some embodiments, may be threaded.

The rails **504** for use with the twin rail-arm-leg module **730** have fastener holes **514** spaced at periodic distances along the rail **504** like the rails **504** used with the twin rail-arm-leg module **730**, but arranged in a second exemplary embodiment quad-rail beam **754** similar to the first exemplary embodiment quad-rail beam **500**.

The split quad rail-arm-leg module **750** is configured to combine with the rails **504** to make work stations of various configurations. The split quad rail-arm-leg module **750** is configured for two rails **504** to be inserted into each of two partial module interiors **726** of the twin rail-arm-leg module **730**. In each partial module interior **726** one rail **504** is attached to the underside of the upper cross plate **734** with a fastener passing through the fastener holes **514** in the rail **504** and the upper cross plate **734** and the other rail **504** is attached to the topside of the lower cross plate **734** with a fastener passing through the fastener holes **514** in the rail **504** and the lower cross plate **734**.

The typical dimensions for the split quad rail-arm-leg module **750** are 20 inches high and 8½ inches wide across the front. Each partial module interior **726** of the twin rail-arm-leg module **730** is typically 1¼ inches wide between the column **532** and the center column **752**, 6 inches between the two cross plates **534**, and 1½ inches deep. These dimensions are convenient for building industrial workstations, but other dimensions may be used. The cross plates **734** nearest the top of the twin rail-arm-leg module **730** are typically flush with the top of the columns **532**, but in some embodiments, may be positioned lower. While split quad rail-arm-leg module **750** may be freestanding, typically it has one or more horizontal legs (not shown) to give it greater stability.

The split quad rail-arm-leg module **750** may be used to make any of workstation embodiments based on the open quad rail-arm-leg module **530** described herein, the necessary changes being made, including the H module **540**, the I module **620**, the L module **630**, the T module **640**, the X module **650**, the Y module **660**, and the pentagon module **670**.

Arms and Positioning Holders

The Three-Dimensional Positioning and Holding Modular System includes positioning holders for holding workstation accessories such as table tops, lighting fixtures, cabinets, tool holders, computer monitors, etc. Positioning holders for use with the Three-Dimensional Positioning and Holding Modular System are configured for attaching to rails **504** or modules (e. g. an open quad rail-arm-leg module **530**). The positioning holders typically are configured to allow repositioning of the accessory and in some cases, of the positioning holder itself. Some of the positioning holders hold accessories directly, but most do so indirectly though arms **544** that attach directly to the positioning holder. Objects are attached by bolting, pinning, clamping, telescoping, clipping (plastics), wedging or nesting.

The arms **544** in the Three-Dimensional Positioning and Holding Modular System are shaped and sized to have a sliding fit when inserted into the top opening of the columns **532** (or **752**) of any of the rail-arm-leg modules (e.g. **530**, **730**, **750**) or any the positioning holders as described herein. The arms **544** typically have a rectangular cross-section, but may have a circular cross-section, or a cross-section of some other shape. Once inserted and in a desired position, an arm **544** is held in that position with a set screw **552** (See e.g. FIG. **16**) engaged with a threaded hole **516** in the rail support arm bracket **542** or open quad rail-arm-leg module **530**. Alternative embodiments may have other suitable mechanisms for locking the arm **544** in position.

FIG. **14** shows a rail support arm bracket **542** attached to the rails **504** of a quad-rail beam **500** with arms **544** inserted into the rail support arm bracket **542** and into open ends of the columns **532** of a quad rail-arm-leg module **530**. The rail support arm bracket **542** has a function similar to that of the rail support bracket **508**, providing support to the rails **504**, but additionally has the function of providing attachment points for arms **544**. The top and bottom of the rails and arm support bracket **542** have fastener holes **514** for fasteners **512** to pass through, as in the rail support bracket **508**, but the sides are arm tubes **554**, shaped and sized to provide a sliding fit with the arms **544** to be used with them. Once inserted and in a desired position, an arm **544** is held in that position with a set screw **552** turned into a threaded hole in the side of the rail support arm bracket **542**. Alternative embodiments may have other suitable mechanisms for locking the arm **544** in position. The rail support arm bracket **542** may be used at a part of the H module **540** where arms are desired, but horizontal legs **546** are not.

A side mount clamp-on arm bracket **550** is another positioning holder for use with the Three-Dimensional Positioning and Holding Modular System. FIGS. **15**A, **15**B, and **15**C respectively show top, front, and side views of a side mount clamp-on arm bracket **550**. The side mount clamp-on arm bracket **550** comprises an arm tube **554** coupled to an arm bracket plate **555**. The arm bracket plate **555** is configured to clamp onto two rails **504** of a quad-rail beam **500**, a twin rail beam **720**, and has two arm bracket lips **556** that are sized and positioned to match the distance across the rails and hold the side mount clamp-on arm bracket **550** onto the rails **504**. The arm bracket plate **555** has a plurality of fastener holes **514**. Fasteners **512** may pass to these fastener holes **514** and through matching fastener holes **514** in a clamp plate **558** to secure the side mount clamp-on arm bracket **550** to the rails **504**. The arm tube **554** is shaped and sized to provide a sliding fit to the arms **544** to be used with it. The arm tube **554** has a set screw **552** coupled thereto, which is configured to hold in position an arm **544** that has been inserted into the arm tube **554**.

FIG. **16** shows various positioning holders, including the side mount clamp-on arm bracket **550** and the rail support bracket **508**, discussed elsewhere herein, and a top mount clamp-on arm bracket **560** for use with one of the quad-rail beams. The top mount clamp-on arm bracket **560** is configured to attach to the top side of two rails **504** with a clamp plate **558**. The top mount clamp-on arm bracket **560** is intended to support work station accessories computer monitors, tool holders, light fixtures, etc. The top mount clamp-on arm bracket **560** may have a solid bar extending up from the clamp plate or may have an arm tube **554** extending up from the clamp plate.

A quad rail cable cradle **572** is another type of positioning holder for use with the Three-Dimensional Positioning and Holding Modular System. FIG. **17** shows several quad rail cable cradles **572** attached to the top two rails **504** of a quad-rail beam **500** or one of the workstation module embodiments. The quad rail cable cradles **572** insert between the rails **504** clip onto the rails **504**. Typically, a quad rail cable cradle **572** has a sliding fit on the rails **504** and is held in place primarily by gravity, but other quad rail cable cradles **572** may have a tighter fit to hold them in place. Power and communications cables may be run to workstation accessories using the quad rail cable cradles **572**.

An S clip mounting **614** is another type of positioning holder for use with the Three-Dimensional Positioning and Holding Modular System. FIG. **18** shows an S clip mounting **614** comprising two S clips **590** and a rail mount plate **588**. The two S clips **590** each have a fastener hole **514** and the rail mount plate **588** has two corresponding fastener holes **514** positioned within the rail mount plate **588**. When S clips **590** are position on opposing surfaces of two parallel rails **504** of a quad-rail beam **500**, a twin rail beam **720** or one of the workstation modules, the fastener holes **514** of the rail mount plate **588** line up with the fastener holes **514** of the S clips **590**. A fastener **512** is passed through each of the fastener holes **514** of the rail mount plate **588** and through the fastener hole **514** of the corresponding S clip **590**. The S clips **590** and the rail mount plate **588** pinch the two parallel rails **504** between them, holding the s clip mounting **614** securely in place. The rail mount plate **588** may have accessories attached directly thereto, or indirectly via other positioning holders attached to the rail mount plate **588**. The fastener **512** may be a rivet, a threaded cap screw and nut or other appropriate type of fastener. The fastener holes **514** are typically unthreaded but may be threaded.

A channel-to-rail mounting **616** is another type of positioning holder for use with the Three-Dimensional Positioning and Holding Modular System. FIG. **19** shows a channel-to-rail mounting **616** comprising a channel bar **618** and a rail mount plate **588**. Two fastener holes **514** positioned within the rail mount plate **588** such that when two fasteners **512** are passed through the two fastener holes **514**, the two fasteners **512** contact opposing surfaces of two parallel rails **504** of a quad-rail beam **500**, a twin rail beam **720** or one of the workstation modules. The fasteners **512**, which are threaded, engage with a strut-nut within the channel of the channel bar **618**. The channel bar **618** and the rail mount plate **588** pinch the two parallel rails **504** between them, holding the channel-to-rail mounting **616** securely in place. The rail mount plate **588** may have accessories attached directly thereto, or indirectly via other positioning holders attached to the rail mount plate **588**.

A single drop-on rail clip bracket **602** is another type of positioning holder for use with the Three-Dimensional Positioning and Holding Modular System. FIG. **20** shows a single drop-on rail clip bracket **602** comprising an arm tube **554** coupled with two tube nesting brackets **604**. Each tube nesting bracket **604** comprises two plates coupled at right angles. The single drop-on rail clip bracket **602** is configured so that it can be dropped onto a set of two parallel rails **504** of a quad-rail beam **500**, one rail **504** positioned over the other rail **504**. Each of the two rails **504** enters a space created between one of the two tube nesting brackets **604** and the arm tube **554** with a sliding fit (or looser). Each tube nesting bracket **604** rests on the top of its respective rail **504**. The single drop-on rail clip bracket **602** is held in place by gravity alone, although in some alternative embodiments, one or both of the tube nesting brackets **604** has a threaded fastener hole and set screw to hold the single drop-on rail clip bracket **602** in place. The single drop-on rail clip bracket **602** function and purpose is similar to that of the side mount clamp-on arm bracket **550** (See FIGS. **15**A-**15**C), but with a different way of mounting to the rails **504**. The arm tube **554** is shaped and sized to provide a sliding fit to the arms **544** to be used with it. The arm tube **554** may have a threaded fastener hole with a set screw, which is configured to hold in position an arm **544** that has been inserted into the arm tube **554**. The single drop-on rail clip bracket **602** may also be configured so that it can be dropped onto the two parallel rails **504** of a twin rail beam **720**. In which case, the single drop-on rail clip bracket **602** may have fastener holes **514** in the tube nesting bracket **604** to match up with the fastener holes **514** in the rails **504** of the twin rail beam **720**, allowing a fastener to pass through and couple the single drop-on rail clip bracket **602** to the rails **504**.

FIGS. **21**-**23** show several single rail holders. FIG. **21**A shows a perspective view of a single rail single fastener clip **606**. The single rail single fastener clip **606** is configured to clip onto a single rail **504**. The single rail single fastener clip **606** has a tab with a fastener hole **514** to which may be attached a small workstation accessory. The single rail single fastener clip **606** is configured as a short three-sided rectangular tube, with a lip that on the fourth side. The single rail single fastener clip **606** is slightly larger than the rails **504** to which it is designed to clip around with a tight fit. The single rail single fastener clip **606** is made of a flexible, elastic material, typically plastic, that allows the opening on the fourth side to expand enough for the lip to pass around the rail **504**, then snap back when the rail **504** is fully nested in the single rail single fastener clip **606** with the lip preventing the single rail single fastener clip **606** from slipping off the rail **504**. FIG. **21**B show a perspective view of a single rail double fastener clip **610**. The single rail double fastener clip **610** is similar to the single rail single fastener clip **606**, but does not have a lip on the fourth side, which instead is completely open. The single rail double fastener clip **610** has an additional tab with a fastener hole **514**. To prevent the single rail double fastener clip **610** from slipping off the rail **504**, the single rail double fastener clip **610** relies on the accessory attaching to both fastener holes **514** with fasteners.

FIG. **22**A shows a perspective view of a single rail wire holding clip **608**. The single rail wire holding clip **608** is similar to the single rail single fastener clip **606** except instead of the tab with the fastener hole **514**, the single rail wire holding clip **608** has a trough with cable retaining material **594**. The intended use for the single rail wire holding clip **608** is to clip to a rail **504** in a workstation and guide cables for power or communications. An alternative way to guide cables is shown in FIG. **22**B which shows a perspective view of a Velcro strip **600** holding a service cable **592** to a rail **504**.

A double drop-on rail clip bracket **724** is another type of positioning holder for use with the Three-Dimensional Positioning and Holding Modular System. FIG. **30** shows a double drop-on rail clip bracket **724** clipped on to the rails **504** of a twin rail H module **722**. The double drop-on rail clip bracket **724** comprises two arm tubes **554** coupled by a single bolt plate **740** a single fastener hole **514**. The double drop-on rail clip bracket **724** is configured to drop on to the twin rail beam **720** with a sliding fit. The double drop-on rail clip bracket **724** is coupled to the twin rail beam **720** with a single fastener that passes through the fastener hole **514** in the bolt plate **740** of the double drop-on rail clip bracket **724** and through the fastener hole **514** of a top rail **504** of the twin rail beam **720**.

A top mount bolt-on arm bracket **758** is another type of positioning holder for use with the Three-Dimensional Positioning and Holding Modular System. FIG. **32** shows a top mount bolt-on arm bracket **758** that has an arm tube **554** coupled to two bolt plates **740**. The bolt plates **740** each have a single fastener hole **514**. The fastener hole **514** of one of the two bolt plates **740** is configured to line up with a fastener hole **514** in one of the upper rails **504** of a second embodiment quad-rail beam **754** and the fastener hole **514** of the other of the two bolt plates **740** is configured to line up with a fastener hole **514** in the other of the upper rails **504** of a second embodiment quad-rail beam **754**. Once so aligned, fasteners may be passed through the fastener hole **514** to couple the top mount bolt-on arm bracket **758** to the rails **504**.

A side mount bolt-on arm bracket **756** is another type of positioning holder for use with the Three-Dimensional Positioning and Holding Modular System. FIG. **32** shows a side mount bolt-on arm bracket **756** that is similar to the side mount clamp-on arm bracket **550** (see FIG. **16**). The side mount bolt-on arm bracket **756** has an arm tube **554** and two bolt plates **738** for coupling with the rails **504** of a second embodiment quad-rail beam **754**. The bolt plates **738** each have two fastener holes **514** that are configured to line up with the fastener holes **514** in the rails **504** of a second embodiment quad-rail beam **754**, the fastener holes **514** in the upper bolt plate **738** lining up with the fastener holes **514** in the upper two rails **504**, and the fastener holes **514** in the lower bolt plate **738** lining up with the fastener holes **514** in the lower two rails **504**. Once so aligned, fasteners may be passed through the fastener hole **514** to couple the side mount bolt-on arm bracket **756** to the rails **504**. Some side mount bolt-on arm bracket **756** may be configured for coupling with the rails **504** of a twin rail beam **720**, with shorter bolt plates **738**, each with only a single fastener hole **514**.

Workstation Arrangements Based on the Workstation Modules

FIG. **23** shows a perspective view of a first representative workstation arrangement **566** based on a first embodiment workstation module (H module) **540**, which in turn may be based on the open quad rail-arm-leg module **530** or twin rail-arm-leg module **730**. The workstation arrangement **566** comprises a H module **540** with two double-arm table support brackets **564** and two single-arm table support brackets **562**. Tables are omitted in FIG. **23** to better show the underlying structure of the workstation arrangement **566**. Each of the two double-arm table support brackets **564** is coupled to two arms **544**, which insert into the columns **532** of one of the two quad rail-arm-leg modules **530** of the H module **540**. Each of the single-arm table support brackets **562** is coupled to an arm **544**, which is inserted into a side mount clamp-on arm bracket **550** mounted to two of the four rails **504**.

FIG. **24** shows a side view of the first representative workstation arrangement **566** based on a first embodiment workstation module (H module) **540**. The double-arm table support bracket **564** are not shown to better illustrate the operation of the single-arm table support brackets **562**. Table tops **568** are coupled to the single-arm table support brackets

562. The single-arm table support brackets 562 are configured to allow the table tops 568 to tilt to a desired work position. The tilt and height of each table top 568 can be adjusted independently and locked in a desired position with the set screws 552 on the single-arm table support bracket 562 and side mount clamp-on arm bracket 550 respectively.

FIG. 25 shows a perspective view of a second representative workstation arrangement 570 based on a first embodiment workstation module (H module) 540 with various positioning holders. This second embodiment workstation arrangement 570 has multiple first embodiment rail-arm-leg assemblies 540 connected in series. Quad rail-arm-leg modules 530 are used to splice different sections of rails 504.

FIG. 26 shows a perspective view of a third embodiment workstation arrangement 680 based on the sixth embodiment workstation module 660 (Y module). A Y-shaped table top 685 is positioned over and coupled to the Y module 660 with a plurality of arms 544 and double-arm table support bracket 564. Three circular table top 686 are attached at the end of each point of the Y module 660 on double-arm table support brackets 564. Three Y module interstitial table tops 682 are attached on arms 544 between the Y-shaped table top 685 and the three circular table tops 686. The locations of two stools 689 are shown as they may be used with third embodiment workstation arrangement 680.

FIG. 27 shows a perspective view of a fourth embodiment workstation arrangement 690 based on the seventh embodiment workstation module 670 (pentagon module). A pentagon-shaped table top 695 is positioned over and coupled to the pentagon module 670. Five circular table top 686 are attached at the end of each point of the pentagon module 670 on double-arm table support brackets 564. Three pentagon module interstitial table top 692 are attached on arms 544 between the pentagon-shaped table top 695 and the five circular table tops 686. The locations of five stools 689 are shown as they may be used with fourth embodiment workstation arrangement 690.

FIG. 28 shows a perspective view of a fifth embodiment workstation arrangement 700 based on the fifth embodiment workstation module 650 (X module). A X-shaped table top 705 is positioned over and coupled to the X module 650. Four circular table top 686 are attached at the end of each point of the X module 650 on double-arm table support brackets 564. Four X module interstitial table tops 702 are attached on arms 544 between the X-shaped table top 705 and the four circular table tops 686. The locations of four stools 689 are shown as they may be used with fifth embodiment workstation arrangement 700.

What is claimed is:

1. A workstation module comprising:

a first rail beam comprising a plurality of rails that are tubular and rectangular in cross-section, arranged in parallel lengthwise, wherein the first rail beam is configured so that between each of the plurality of rails there is a gap that is at least as large as a largest cross-sectional dimension of one of the plurality of rails;

a first rail-arm-leg module comprising a plurality of columns coupled by a bottom plate and a plurality of cross plates, with the columns oriented orthogonal to the cross plates and the bottom plate, wherein the columns and the cross plates define a module interior;

wherein each of the rails of the first rail beam is in sliding contact with at least one of the columns of the first rail-arm-leg module; and

wherein the first rail beam is coupled to the first rail-arm-leg module.

2. The workstation module of claim 1,

wherein the columns comprise hollow tubes with open top ends; and

further comprising an arm positioned within one of the columns of the first rail-arm-leg modules, the arm shaped and sized to provide a sliding contact with the column.

3. The workstation module of claim 1,

wherein the first rail beam fits into the module interior of the first rail-arm-leg module with a sliding fit.

4. A workstation module comprising:

a first rail beam comprising a plurality of rails that are tubular and rectangular in cross-section, arranged in parallel lengthwise, wherein the first rail beam is configured so that between each of the plurality of rails there is a gap that is at least as large as a largest cross-sectional dimension of one of the plurality of rails;

a first rail-arm-leg module comprising a plurality of columns coupled by a bottom plate and a plurality of cross plates, with the columns oriented orthogonal to the cross plates and the bottom plate, wherein the columns and the cross plates define a module interior;

wherein each of the rails of the first rail beam is in sliding contact with at least one of the columns of the first rail-arm-leg module;

wherein the first rail beam is coupled to the first rail-arm-leg module;

wherein the first rail beam fits into the module interior of the first rail-arm-leg module with a sliding fit;

wherein the first rail beam is a quad-rail beam with four rails arranged in a pattern that is rectangular in cross-section;

wherein the first rail-arm-leg module is an open quad rail-arms-leg module with two columns and two cross plates;

further comprising two clamp plates positioned within the module interior, wherein each clamp plate is adjacent two of the four rails; and

further comprising four fasteners, each fastener passing through one of the cross plates, through one of the clamp plates and passing adjacent to one of the rails.

5. The workstation module of claim 4, further comprising an arm bracket clamped to two of the plurality of rails with a clamp plate and with at least two fasteners;

wherein the arm bracket comprises an arm tube coupled to an arm bracket plate;

wherein the arm bracket plate has two arm bracket lips that are positioned to match a distance across the rails and hold the arm bracket onto the rails; and

an arm positioned within the arm tube, the arm shaped and sized to provide a sliding contact with the arm tube.

6. The workstation module of claim 3,

wherein the first rail beam is a twin rail beam with two rails, one above the other;

wherein the first rail-arm-leg module is a twin rail-arms-leg module with two columns and two cross plates; and

wherein one of the two rails is coupled to the one of the cross plates and the other of the two rails is coupled to the other of the two cross plates.

7. The workstation module of claim 6,

wherein the two rails each have a fastener hole penetrating through the rail orthogonal to a long axis of the rail;

wherein the cross plates each have a fastener hole;

wherein one of the two rails is coupled to the one of the cross plates with a first fastener passing through the fastener holes in the rail and the cross plate; and wherein the other of the two rails is coupled to the other of the two cross plates with a second fastener passing through the fastener holes in the rail and the cross plate.

8. The workstation module of claim **7**,

wherein the two rails are perforated rails with fastener holes penetrating through the rail orthogonal to a long axis of the rail, the fastener holes spaced at periodic intervals along the long axis of the rail.

9. The workstation module of claim **8**, further comprising

a double drop-on rail clip bracket with two arm tubes coupled by a single bolt plate with a single fastener hole;

wherein the double drop-on rail clip bracket is configured to drop on to the twin rail beam with a sliding fit; and

wherein the double drop-on rail clip bracket is coupled to the twin rail beam with a single fastener that passes through the fastener hole in the bolt plate of the double drop-on rail clip bracket and through the fastener hole of a top rail of the twin rail beam.

10. The workstation module of claim **8**, further comprising

a side mount bolt-on arm bracket with an arm tube and two bolt plates each with a fastener hole configured to line up with a fastener hole in one of the rails of the twin rail beam;

wherein the fastener holes in one of the bolt plates lining up with the fastener hole in an upper two rail of the twin rail beam, and the fastener hole in the other bolt plate lining up with the fastener hole in a lower two rail of the twin rail beam; and

two fasteners passed through the fastener holes in the side mount bolt-on arm bracket and the rails.

11. The workstation module of claim **3**,

wherein the first rail beam is a quad-rail beam with four rails arranged in a pattern that is rectangular in cross-section;

wherein the four rails are perforated rails with fastener holes penetrating through the rail orthogonal to a long axis of the rail, the fastener holes spaced at periodic intervals along the long axis of the rail;

wherein the first rail-arm-leg module is a split quad rail-arms-leg module with four cross plates and with three columns, including a center column and two side columns;

wherein the module interior is divided by the center column into two partial module interiors;

wherein each of the rails of the first rail beam is in sliding contact with at least one of the side columns of the first rail-arm-leg module and in sliding contact with the center column; and

wherein each of the rails is coupled to the one of the cross plates.

12. The workstation module of claim **11**, further comprising

a top mount bolt-on arm bracket with an arm tube coupled to two bolt plates, the bolt plates each with a single fastener hole;

wherein the top mount bolt-on arm bracket is configured for the fastener hole of one of the two bolt plates to line up with a fastener hole in an upper one of the rails of the quad-rail beam and the fastener hole of the other of the two bolt plates to line up with a fastener hole in another upper one of the rails of the quad-rail beam; and

two fasteners passed through the fastener holes in the top mount bolt-on arm bracket and the rails.

13. The workstation module of claim **11**, further comprising

a side mount bolt-on arm bracket with an arm tube and two bolt plates each with two fastener holes configured to line up with the fastener holes in the two of the rails of the quad-rail beam;

wherein the fastener holes in one of the bolt plates lining up with the fastener holes in an upper two rails of the quad-rail beam, and the fastener holes in the other bolt plate lining up with the fastener holes in a lower two rails of the quad-rail beam; and

four fasteners passed through the fastener holes in the side mount bolt-on arm bracket and the rails.

14. The workstation module of claim **1**,

a second rail-arm-leg module coupled to the first rail beam.

15. The workstation module of claim **14**,

a second rail beam coupled the first rail beam; and

a third rail-arm-leg module coupled to the second rail beam.

16. The workstation module of claim **15**,

a third rail beam coupled the first rail beam; and

a fourth rail-arm-leg module coupled to the third rail beam.

17. The workstation module of claim **1**,

a Y module center coupler;

a second rail-arm-leg module coupled to a second rail beam;

a third rail-arm-leg module coupled to a third rail beam; and

wherein the first rail beam, the second rail beam and the third rail beam are coupled to the Y module center coupler.

* * * * *